BUILDING CONSTRUCTION
AND SUPERINTENDENCE

PART III

Trussed Roofs and Roof Trusses

BY F. E. KIDDER, C.E., PH.D.

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Building Construction and Superintendence

Part 1. Masons' Work.

By F. E. Kidder, C.E. Ph.D., Revised by Thomas Nolan, M.S., A.M.

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BUILDING-CONSTRUCTION

AND SUPERINTENDENCE.

BY

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REWRITTEN AND ENLARGED

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PART II,

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PREFACE TO FIRST EDITION.

IT has been the aim of the author, in preparing this work, to furnish a series of books that shall be of practical value to all who have to do with building operations, and especially to architects, draughtsmen and builders. In this volume an attempt has been made to describe those materials and methods of construction that come within the ordinary province of the carpenter, or are usually included in the carpenter's specifications.

In treating the various subjects that come within the scope of the book, the descriptive method used in Part I, with numerous illustrations, has been followed, as this appears to be the most practical method of accomplishing the end in view. But little space has been given to methods of determining the strength of materials, these having already been sufficiently covered in various works treating particularly of such matters, the especial aim of the author being rather to show how the various kinds of work should be done, what materials should be used and how the parts of buildings should be put together.

To do this in a manner that would be of sufficient practical value to warrant its being done at all, has required the making of a large number of detail drawings, which, while they have greatly increased the labor of preparation and delayed the publication, will, the author dares to believe, prove of great assistance to the young architect and draughtsman, and he trusts of some value to experienced architects and builders.

The illustrations may not be considered as models of draughtsmanship, but on a small scale are such as are usually required in making working drawings and in explaining the method of construction to be pursued. It is hoped that their value may be in proportion to the labor and thought that have been expended upon them.

The various materials employed by the carpenter, or with which he usually has to do, have also been carefully considered, with the view of enabling the architect and builder to employ them wisely, and to distinguish between the various kinds and qualities.

An especial effort has been made, in describing different forms of construction, not to follow entirely the methods of one section of the country, but rather to give the different methods pursued by different architects and in different localities, contrast them, and bring out their relative advantages. In this the author has been greatly assisted by many prominent architects, and by his own experience in both the Eastern and Western portions of the country.

The method of paragraphing the subjects followed in Part I has been retained, partly for convenience in making cross references and also for greater convenience in the class room. Much pains have been taken to make the Index as complete as possible, using the most suggestive terms, so that any subject may readily be found.

In referring to the supervision of the work the author has attempted to call attention to the defects commonly found in building materials and to inferior methods of construction, and various ways in which the work is often slighted.

The general duties of a superintendent have been so well set forth in Mr. T. M. Clark's well-known work, "Building Superintendence," that it seems unwise to go more fully into this part of the subject, especially as the best preparation for efficient supervision is a thorough knowledge of how the work should be done, and that the author has tried to impart.

There are so many patented articles and devices used in connection with the carpenter's work that are not only desirable, but often absolutely necessary to the proper equipment of a building, and with which, therefore, the architect should be acquainted, that it has been necessary to describe or refer to quite a number, but only such have been recommended as have been thoroughly investigated, or which the author has successfully used in his own practice.

In conclusion, the author wishes to acknowledge the great assistance he has received from various architects, and especially from Prof. C. A. Martin, of Cornell University, in regard to various details of construction, and also from several manufacturers of builders' hardware for information and illustrations.

The author will appreciate any suggestions that may be made looking to the improvement of future editions, or any corrections of errors that may be discovered.

F. E. KIDDER.

Denver, August 1, 1898.

PREFACE TO REVISED EDITION.

THE conditions under which the work of the revision of "Building-Construction and Superintendence, Part II, Carpenters' Work," was undertaken were similar to those which obtained in the revision of Part I, "Masons' Work." One of the paragraphs of the preface to the new edition of this latter work expresses, in general, these circumstances; and, as they are much the same for both books, the paragraph mentioned is quoted here. With the words "Masonry-Construction" changed to "Carpentry-Construction," it explains clearly the purpose of this treatise and the policy of the author of the revision.

"In offering this new edition of 'Building-Construction and Superintendence, Part I, Masons' Work,' to the public, the author of the revision has constantly borne in mind the original purpose of the book as set forth by Mr. Kidder in the preface to the first edition. He has endeavored to bring it down to the present day in such form that it will continue to hold a high place as one of the standards of the best contemporary practice in the elements of architectural masonry construction and superintendence. While he has endeavored to explain the principles of the subject in a way that may be readily understood and followed by all who are in any way connected with or interested in building operations, whether architects, engineers, contractors, students, artisans or the general public, he has, at the same time, tried to set forth these principles and methods of procedure in a scientific manner, preserving and further strengthening the purpose of the work, not only as a hand-book for professional and commercial use and reference, but also as a text-book for schools and colleges. He must leave it to those who use the revised work to decide the measure of his success."

The author of the new "Carpenters' Work" has endeavored to make it a better book on American practice in this branch of building-construction than any heretofore published. It is much more than a mere revision. The original matter has been almost doubled in amount and the book has been literally rewritten from beginning to end. Instead of five hundred and twenty-five figures, the former number, there are eight hundred and thirty, and as many so-called "figures" have from two to a dozen separate diagrams, the new book has over one thousand illustrations of carpentry-construction.

The number of tables has been more than doubled, having been increased from twenty-four to fifty.

The author of the revision has taken the greatest pains to have all data accurate and authoritative and has written more than three thousand letters to collect and verify information bearing upon the work. References to the sources of information are given wherever possible, either in the text or in footnotes.

In order to make the treatise a unit, it was deemed necessary, after the new or revised matter was classified, edited and put in place, to rearrange, recast and often to entirely rewrite the matter relating to unchanged facts, thus making the phraseology and general style of presentation the same throughout.

A careful examination of every article in the book, and a revision of every one in which changes, omissions or additions of data or methods of procedure were considered necessary or advisable, constituted an important part of the work included in the work of bringing out the new edition. Some articles have been omitted and many new ones added. Some chapters have been entirely rewritten. An analysis of the matter of each chapter has been made and a corresponding classification added in the form of numbered chapter-subdivisions. Descriptive captions have been added to every article and to every figure. The number of each chapter has been added to the page-caption of every left-hand page in order to facilitate the finding of cross-references, which have been greatly increased in number.

An unusually comprehensive Index has been added and the form of the Table of Contents is such that all general data of the text or any particular article may be readily found from it. Readers should consult the Table of Contents as frequently as the Index, the latter being used for more detailed or specific reference.

Chapter I, "The Building and Finishing-Woods of the United States," has been entirely rewritten and much enlarged and no pains have been spared to make it an authoritative, comprehensive and useful treatment of the subject in a condensed and convenient form.

Chapter II, "Wood Framing," has been much enriched with new drawings of timber framing, beam and girder-supports and connections, partition-construction, roof-construction, dormer and eyebrow-windows, etc.

Chapter III, "Sheathing, Frames, Sashes and Glazing," contains much new text-matter and new illustrations relating to window-frames and door-frames of all kinds for frame or masonry walls; transoms; casement, revolving and pivoted sashes; and oriel windows. It contains, also, entirely new matter, copiously illustrated, on Modern Store-Front Construction. The subject of Window-Glass and Glazing, including sheet glass, plate glass, figured glass, prism-glass, and wire-glass and glass for skylights, mirrors, etc., has been brought down to date by leading manufacturers and others to whom the matter of the various subdivisions has been submitted.

Chapter IV, "Outside Finish and Roofing," contains many pages of new descriptive matter and an unusually large number of new figures explaining the details of the construction of outside wood finish. The subjects of Eaves, Cornices and Gutters, and of Porches and Piazzas especially, are amplified by many new illustrations, and much has been added to the subject of Dormers, Skylights and Roofing. All data referring to Metalwork in its relation to woodwork, including metal roofs, flashings, snow-guards, etc., has been thoroughly revised.

Chapter V, "Interior Woodwork," has been, in many parts, rearranged, and all the matter reclassified. Much new data and numerous new illustrations have been added, especially matter relating to the subjects of Prep-

arations for Tile Floors; Metal Corner-Beads; and Veneered, Patented and Revolving Doors. The subjects of Metal Doors, Sashes, Frames and Trim are introduced for the first time, with many constructional details and examples from contemporary work, and a brief history of the development of this important type of interior finish is added. The whole subject of Inside Shutters, Blinds and Coiling Partitions has been submitted to various experts and authorities and revised in all its details. The subject of Wood Flooring has been entirely rewritten, as the methods employed in this branch of building-construction have been revolutionized since the first edition of this book was published. This division of Chapter V has much new matter, relating especially to Widths, Thicknesses and Lengths of Flooring, Grading-Rules, Amount of Flooring Required, Methods of Laying and Nailing, Parquet and Parquetry Flooring and Flooring for Fire-Proof Buildings.

Chapter VI, "Builders' Hardware," is another chapter that has been virtually rewritten in bringing it down to date. The detailed matter in it has been submitted to five of the leading hardware-manufacturers, who have revised, added or omitted data wherever necessary to make the information authoritative. In addition to this, different divisions of the subject dealing with various hardware specialties have been sent to representative experts in those special details. Many new drawings have been made to clearly illustrate the mechanism or application of different fixtures. In addition to the thorough revision of finished hardware, even the matter relating to Rough Hardware, such as Nails, Screws, Bolts, Sash-Cords, Chains, Ribbons, Weights etc., has been passed upon by recognized experts in each of these specialties. The different Methods of Specifying Hardware are explained more fully than ever before in any work in Carpentry-Construction, and the various Forms of Hardware-Specifications are added, with a comparison of their relative advantages and disadvantages.

Chapter VII, "Heavy Framing," contains new matter relating especially to the framing of Non-Fire-Proof Stores, Warehouses, etc., Metal Columns and Connections of Floor-Joists to Girders. New articles, with descriptive text and numerous illustrations, and relating to joints in Heavy Wood Framing, and new text and figures illustrating the construction of Sidewalk-Platforms, Bridges and Sheds, have been added; and the entire chapter-subdivision on Mill-Construction has been rewritten and copiously illustrated with new drawings taken from the most approved contemporary practice.

Chapter VIII, "Specifications," has been rearranged, its matter submitted to different authorities on the different subjects considered, reclassified and redivided into numbered and captioned articles, and changed throughout to make it uniform in its phraseology. A model specification on Painters' Work, which it is hoped will prove of value to the architectural profession and which has been generally commended by the associations of house-painters and decorators, is added for the first time.

The Appendix, comprising thirty-nine Tables and much useful data relating to the Strength of Materials, has been greatly expanded. It is divided into seventeen subdivisions treating of the Strength and Stiffness of Wooden, Stone and Concrete Beams and the Safe Loads for the same; the Maximum

Spans for Floor-Joists, Ceiling-Joists and Rafters; the Strength of Wooden, Cast-Iron and Steel-pipe Columns; the Ultimate and Working-Stresses for Wood and Other Building Materials; the Building Laws of different cities relating to Unit Stresses for Woods; the Tensile Strength of Rods; the Tests of the Adhesive Resistance of Nails; and an illustrated critical article by the late Mr. F. E. Kidder on the Selection and Design of Joist-Hangers and Wall-Hangers.

Throughout the entire revision the writer has, wherever possible, referred to the sources of information, either in foot-notes or in the body of the text itself. When necessary, the names and addresses of manufacturers of and dealers in materials and appliances used in carpentry-construction have been given. To all who have assisted in any way, the author of the revision wishes to express his thanks.

He desires to acknowledge his indebtedness to many architects, engineers and members of the faculties of the Schools of Architecture, and especially to Professor Francis W. Chandler, Professor Clarence A. Martin, Professor Charles P. Warren and Mr. Frank M. Snyder for permission to redraw and adapt for use in the new edition many valuable illustrations taken from their own works on carpentry-construction; to Mr. Henry S. Harvey, Mr. G. O. Stedman and Mr. L. G. Lyman, for work on new illustrations; and to Mr. H. A. Blogg and Mr. T. Z. Talley for most valuable assistance throughout in collecting and arranging material, and in proof-reading and indexing.

The writer is much indebted, also, to Mrs. F. E. Kidder for many helpful suggestions pertaining to the revision of the work.

THOMAS NOLAN.

Philadelphia, Pa., August, 1913.

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struction and finishing comes from what are known as "exogenous" trees, or those which increase in size by the formation of new wood each year on the outer surface. "Endogenous" trees, such as the palm or bamboo, are those which increase from within. Exogenous trees are covered with a more or less scaly material called "bark," which envelopes the wood and is removed in the process of manufacture into "lumber." Bark is unusual on endogenous trees.

The wood of these trees is made up of bundles of long tubes, cells and fibers, the long axes of which are generally parallel to the stem of the tree. Crossing these fibers in a radial direction from the pith to the bark are others known as "pith-fibers" or "medullary rays," serving to bind the whole together. Besides these wood

Fig. 1. Wood-Fibers and Medullary Rays.

Fig. 2. Block of Oak. *CS*, cross-section; *RS*, radial section; *TS*, tangential section; *mr*, medullary or pith-ray; *a*, height, *b*, width and *c*, length of a pith-ray.

fibers there are resin-ducts scattered through the wood of the pines and spruces, and hollow ducts or vessels in the wood of the broad-leaved trees.

These fibers and ducts vary in different kinds of trees in shape and disposition, thus giving rise to differences in structure; and it is often by microscopical examination alone that the structure of different varieties of the same species of wood can be determined.

The structure of the wood determines to a large extent its appearance when finished, and has a marked influence, also, upon its physical and mechanical properties.

Fig. 1 shows a bundle of wood fibers, *a b*, highly magnified, with the pith-rays or medullary rays, *c d*, running at right-angles to them.

Fig. 2 shows a block of oak, not magnified, in which the medul-

lary rays are very prominent. They occur in all woods but are not generally noticed in the soft varieties. They give the peculiar silver-mottled effect seen in quarter-sawed oak, and add much to the appearance of most of the hardwoods. They form, also, a large part of the wood of all trees, some of the pines, for example, having over 15,000 to one square inch of tangential section; and even in the oaks the very large rays, which are readily visible to the eye, represent scarcely a hundredth part of the number which the microscope reveals. Besides affecting the appearance of the wood the medullary rays greatly affect, also, its shrinkage and checking in seasoning and have much to do with its strength.

3. GROWTH OF THE TREE. The process of growth of exogenous trees in a temperate climate is as follows:

> "In the spring the roots absorb from the soil juices, which are converted into sap and ascend through the cellular tubes to form the leaves. At the upper surface of the leaves the sap gives off moisture, absorbs carbon from the air and becomes denser. After the leaves are full-grown, vegetation is suspended until autumn, when the sap in its altered state descends, chiefly between the wood and the bark, where it deposits a layer of new wood (the annual ring for that year), a portion at the same time being absorbed by the bark. The new wood thus formed covers all parts of the stem and branches."

As the tree increases with age the inner layers become choked or filled with the secretionary substance peculiar to the tree and fall out of use, except as they perform the mechanical function of keeping the tree from breaking under its own weight or from the force of the wind. This process of growth, therefore, produces two kinds of wood in the same tree: the "sap-wood" and the "heart-wood."

Practically speaking, the sap-wood of trees is that portion of the wood in which the cells are open to the upward pressure of the sap. It varies in width and in the number of rings which it contains, even in different parts of the same tree. It varies, also, considerably in different kinds of trees, being small in amount in the hardwoods, long-leaf pines and white pines, and large in the loblolly and Norway pines. The sap-wood possesses little strength and is subject to rapid decay, owing to the great quantity of fermentable matter contained in it.

4. ANNUAL RINGS. The layers of wood formed each year appear as rings on the cross-section of the log, and by counting them the age of that portion of the tree may be determined.

The width of these yearly rings varies greatly in different trees and also in different parts of the same tree. The average width

of the rings in well-grown old white pine will vary from 1/12 to 1/18 of an inch, while in the more slowly growing long-leaf pine it may be from 1/25 to 1/80 of an inch. While these rings are approximately circular in shape, it is very seldom that they form true circles; usually they are oval and at the stump they commonly form an irregular figure.

"The greater regularity or irregularity of the annual rings has much to do with the technical qualities of the timber."

5. SPRING-WOOD AND SUMMER-WOOD. If the annual rings are examined closely it will be noticed that each ring is made up of an inner, softer, light-colored portion, and an outer, firmer and darker-colored portion. Being formed in the earlier part of the season, the inner, light-colored part is termed the "spring-wood," and the outer, darker portion the "summer-wood" of the ring.

The summer-wood is much firmer and heavier than the spring-wood, and hence the greater the proportion of summer-wood to the total volume, the greater will be both the weight and strength of the timber. The darker shade of the summer-wood modifies also the color of the entire piece, and in the pines this color-effect affords a valuable aid in distinguishing the heavy and strong from the light and soft woods.

In some trees like the hard pines the dark summer-wood appears as a distinct band, so that each yearly ring is composed of two sharply defined bands, an inner band of spring-wood and an outer band of summer-wood. But in some cases, even in hard pines, and normally in the wood of white pines, the spring-wood passes gradually into the darker summer-wood, so that a sharply defined line appears only where the spring-wood abuts against the summer-wood of its inner neighbor. It is this clearly defined line which enables the eye to distinguish even the very narrow rings in old pines and spruces.

In a pine board, sawed from near the center of a log, the spring-wood and summer-wood will appear about as shown in Fig. 3, an inner, lighter strip and its outer, darker neighbor always corresponding to one annual ring. If the tree were perfectly straight and the rings of uniform thickness, the spring-wood and summer-wood would appear as parallel bands on the face of a board; but, owing to the irregularity of the growth, the two kinds of wood usually form a variety of pleasing patterns on the face of bastard-sawed lumber. Where a saw-cut passes through a bump or crook of a log, irregular concentric circles and ovals are produced, and on almost all bastard-sawed boards arrow or V-shaped forms occur.

6. SOFTWOODS AND HARDWOODS. Although there is no universally recognized dividing line between these two classes of woods, the "softwoods" are usually cut from the coniferous or needle-leaved trees such as the pine, spruce and cedar, and the "hardwoods" from the broad-leaved trees such as the oak, ash and hickory.

"Though alike in their manner of growth, and therefore similar in their general make-up, conifers and broad-leaved trees differ markedly in the details of their structure and character of their wood. The wood of all conifers is very simple in its structure, the fibers composing the main part of the wood being all alike and their arrangement regular. The wood of broad-leaved trees is complex in structure; it is made up of several different kinds of cells and fibers and lacks the regularity of arrangement peculiar to the conifers." * †

Fig. 3. Pine Board. *CS*, cross-section. *RS*, radial section; *TS*, tangential section; *sw*, summer-wood; *spw*, spring-wood.

Between the softwoods and the hardwoods there is no sharply defined distinction in hardness; some of the hardwoods, such as basswood, poplar and sycamore being softer than some of the pines.

* Bulletin No. 10, "Timber," U. S. Department of Agriculture, Division of Forestry.

† See Kidder's "Architects' and Builders' Pocket-Book." Table, "Relative Hardness of Woods."

"Both in the number of different species or kinds of trees and still more in the importance of their products the conifers and broad-leaved trees far excel the palms and their relatives." *

2. PHYSICAL PROPERTIES AND CHARACTERISTICS OF TIMBER.

7. GRAIN OF WOOD. In common usage wood is said to be "coarse-grained" when its annual rings are wide and "fine-grained" when they are narrow. The term "fine-grained" is sometimes applied, also to those woods which take a high polish, this depending chiefly on their hardness. When the direction of the fibers is parallel to the axis of the stem or limb the wood is "straight-grained," and when the course of the fibers is spiral or twisted around the tree the wood is "cross-grained." Sometimes the fibers take the shape of fine waves, when the wood is said to be "wavy-grained" or "curly-grained," The latter is frequently seen in maple.

The surface under the bark of a tree is not generally uniform and smooth, there being a greater or less number of elevations or depressions; and the same is true of the layers in the interior. In some woods these depressions or elevations remain in only a few layers, while in others they increase from year to year. On tangent boards of such woods the sections of these pits and prominences appear as small circles and give rise to beautiful figures. In maple the tendency to preserve any particular contour is very great, and as the depressions and elevations are usually small and very numerous, they appear on the face of the boards as very fine circlets, and hence the term "bird's-eye" maple. The branches or limbs of a tree, also, affect the grain and appearance of boards cut through or near them.

"At the juncture of a branch with the stem of a tree the fibers on the upper and lower sides of the branch behave differently. On the lower side they run from the stem into the limb, forming an uninterrupted strand or tissue and a perfect union, as shown in Fig. 4. On the upper side the fibers bend aside and are not continuous into the limb."

Owing to this arrangement of the fibers the cleft made in splitting never runs into a knot if started above the limb, but is apt to enter the knot if started below. When limbs die, decay and break off, the remaining stubs are surrounded and finally covered by the growth of the trunk. As long as these knots preserve their natural color they are not classed as "dead" knots, but they are dead, nevertheless, from the point where they cease to be united with the living wood. Dead knots in pine and spruce almost always become loose,

* Bulletin No. 10, "Timber," U. S. Department of Agriculture, Division of Forestry.

so that when the log is sawed into boards the sections of the knots drop out.

If an ax is struck into a piece of wood, as shown in Fig. 5, the cleft projects some distance beyond the blade, the process being not one of cutting, but of overcoming the tension across the grain. The cleft will extend some distance beyond the ax if the wood is very elastic. Splitting is therefore aided by the elasticity and resisted by the shearing strength of the material. Wood splits more easily and naturally along the radius or in the direction of the pith-rays.

"On a cross-section of oak, the same arrangement of pith and bark, of sap-wood and heart-wood, and the same disposition of the wood in well defined concentric or annual rings occur; but the rings are marked by lines, or rows, of conspicuous pores or openings which occupy the greater part of the spring-wood of each ring (Fig. 2), and are, in fact, the hollows of vessels through which the cut has been made. On the radial section, or quarter-sawed board, the several layers appear as so many parallel stripes (Fig. 6); on the tangential section or 'bastard' face, patterns similar to those mentioned for pine wood are observed. But while the patterns in hard pine are marked by the darker summer-wood and are composed of plain, alternating stripes of darker and lighter wood, the figures in oak, and other broad-leaved woods, are due chiefly to the vessels, those of the spring-wood in oak being the most conspicuous (Fig. 6); so that in an oak table the darker, shaded parts are the spring-wood and the lighter, uni-colored parts the summer-wood." *

Fig. 4. Section of Wood showing Portion of the Grain at Base of a Limb. *P*, pith of both stem and limb; 1-7, seven yearly layers of wood; *ab*, knot or basal part of a limb which lived four years, then died and broke off near the stem, leaving the part to the left of *ab*, a "sound" knot and the part to the right a "dead" knot, which would have been soon entirely covered by the growing stem.

Fig. 5. Cleavage or Splitting of Wood.

The tensile and compressive resistance of wood is also much affected by the position of the grain. The perfectly cross-grained

* Bulletin No. 10, "Timber," U. S. Department of Agriculture, Division of Forestry.

piece, *a*, Fig. 7, sustains but from about one-tenth to one-twentieth of the load which is supported by the straight-grained piece *c*; and it is evident that the piece *b*, which represents the ordinary case of

Fig. 6. Thick Plank of Oak in Isometric Perspective.

cross-grain, is likewise weakened by the oblique position of the grain.

This explains the detrimental influence of a knot on the under side

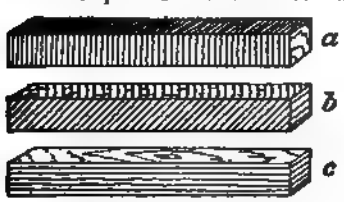


Fig. 7. Straight and Cross-grained Wood.

Fig. 8. Effect of Knots on the Grain of Wood.

of a board, as in Fig. 8. Since the lower side of the board, in bending, is stretched and the upper side compressed, the fibers of the lower side are subjected to tension and the wood of the knot, like the

piece of cross-grained wood, offers little resistance. Commonly, the defect is greatly increased by a season-check in the knot itself; so that the knot affects the strength of a board just as a saw-cut of equal depth affects it.

8. COLOR AND ODOR OF WOOD. *The Color of Wood.* This enhances its beauty, aids in its identification and is of great assistance in judging its quality. Each variety of wood has its own peculiar color, at least for the heart-wood; and this, when known, furnishes a reliable distinguishing mark. Newly formed wood, like that of the few outer rings, has little color. In all trees the sap-wood is generally light in color, and in the hardwoods there is often a great difference in the color of the sap-wood and heart-wood. The color of good timber should be uniform throughout the heart-wood; for when the wood is blotchy or varies much in color from the heart outward, or suddenly becomes pale toward the limit of the sap-wood, it is probably diseased.

"When wood is attacked by fungi it becomes more opaque, loses its brightness and in practice is designated 'dead' as distinguished from 'live' or bright timber. Exposure to air darkens all wood; direct sunlight and occasional moistening hasten this change and cause it to penetrate more deeply. Prolonged immersion has the same effect, pine wood becoming a dark gray, while oak changes to a blackish brown."

The Odor of Wood. The odor is caused by chemical substances contained in it, but which form no part of the wood-substance itself. Exposure to weather reduces and often changes the odor, but most of the softwoods exhale apparently as much odor as ever when a fresh surface is exposed. Many kinds of wood are distinguished by strong and peculiar odors, which aid in identifying the variety, and in some cases give the wood a peculiar value. Decomposition is usually accompanied by pronounced odors, decaying poplar emitting a disagreeable odor, while red oak often becomes fragrant, its scent resembling that of heliotrope.

9. RESONANCE OF WOOD. If a piece of timber is struck with a hammer a sound is emitted which varies in pitch and character with the shape and size of the piece, and also with the kind and condition of the wood. A dull, heavy sound indicates decay. Knots and irregularities in structure, also, affect the character of the sound emitted. Thin boards may be set vibrating by sound-waves produced in the air. This property is utilized in the construction of many musical instruments, in architecture in the construction of sounding-boards and to reinforce the voice of speakers or the music of choirs or orchestras. The property possessed by a sounding-board of responding freely to all the notes of an instrument or of the

human voice depends, first, upon the structure of the wood and, secondly, upon its uniformity throughout. Sounding-boards should be made as thin as practicable; and the wood should be free from knots, cross-grained or resinous tracts and thoroughly and carefully seasoned.

Almost all our broad-leaved woods are excluded from use for sounding-boards because of their irregularity of structure. Many of the conifers are excluded because of lack of strength. Spruce is the favored resonance-wood and is used for sounding-boards in pianos and violins.

10. WEIGHT OF WOOD. The weight of any particular piece of wood depends upon two main factors: the proportion of wood-substance contained in the piece and the amount of water contained in the wood. The weight of the wood-substance is practically the same in all woods, about one and six-tenths times the weight of water. As the wood cells, however, are in most cases filled with air, they reduce the weight of the wood and cause it to float. When wood is immersed in water for a long time the water soaks into the cells; and when most of these become filled it sinks.

When the wall of wood fiber is very thick the wood sinks whether the cells are empty or not. As the proportion of wood-substances in the dark bands of summer-wood is much greater than in the lighter colored spring-wood, it follows that those woods which contain the greatest proportion of summer-wood are the heaviest. The difference in the weight of green wood and that which has been seasoned is due to the quantity of sap contained in the cells of the green wood. Green timbers usually weigh from one-fifth to nearly one-half more than dry timbers; ordinary building timbers, tolerably seasoned, one-sixth more.

In a thrifty young pine the wood is lightest at the center of the tree and grows gradually heavier toward the bark; in an old oak the reverse is true. The weight of wood is in itself an important quality. It assists in identifying different woods, and light weight, when coupled with great strength and stiffness, makes a wood especially valuable for many purposes. To a large extent, also, weight indicates the strength of wood, at least of the same species. For any given species of timber and for any given degree of dryness, the strength is almost directly proportionate to the weight.

The weight of kiln-dried wood of different species is given by Mr. Roth as follows, the first column indicating the kind of wood, the second column the specific gravity or density, the third column the weight of one cubic foot and the fourth the weight of 1,000 feet of lumber:

TABLE I.

Approximate Weight of Kiln-dried Wood of Different Species.

Kind of wood.	Specific gravity or density.	Weight. One cubic foot.	Weight. 1,000 feet of lumber.
		Pounds.	Pounds, Average.
(a) Very heavy woods: Hickory, oak, persimmon, osage orange, black locust, hackberry, blue beech, best of elm and ash........................	.54—1.07	41—54	3,700
(b) Heavy woods: Ash, elm, cherry, birch, maple, beech, walnut, sour gum, coffee tree, honey locust, best of southern pine and tamarack	.51— .94	36—45	3,200
(c) Woods of medium weight: Southern pine, pitch-pine, tamarack, Douglas fir, western hemlock, sweet gum, soft maple, sycamore, sassafras, mulberry, light grades of birch and cherry........	.31— .85	30—44	2,700
(d) Light woods: Norway and bull pine, red cedar, cypress, hemlock, the heavier spruces and firs, redwood, basswood, chestnut, butternut, tulip, catalpa, buckeye, heavier grades of poplar	.31— .85	24—41	2,200
(e) Very light woods: White pine, spruce, fir, white cedar, poplar	.31— .59	20—30	1,800

The weight of ordinary lumber as found in lumber-yards will generally average 33 per cent heavier than the above values.*

11. MOISTURE IN WOOD.† This article is taken largely from the bulletins of the United States Department of Agriculture.

"Water may occur in wood in three conditions: (1) It forms over 90 per cent of the life-giving contents of the living cells; (2) it saturates the walls of all cells, and (3) it entirely, or at least partly, fills the cavities of the lifeless cells, fibers and vessels. In the sap-wood of pine it occurs in all three forms; in the heart-wood it merely saturates the walls. Of 100 pounds of water associated with 100 pounds of dry-wood substance in 200 pounds of fresh sap-wood of white pine, about 35 pounds are needed to saturate the cell-walls, less than 5 pounds are contained in the living cells and the remaining 60 pounds partly fill the cavities of the wood-fibers. This latter forms the sap as ordinarily understood. It is water brought from the soil, containing small quantities of mineral salts; and in certain species of trees, such as maple and birch, it contains also, at certain times, a small percentage of sugar and other organic matter. These organic substances are the dissolved reserve-food, stored during winter in the pith-rays of the wood and bark; but generally but a mere trace of them is to be

* See Tables XXXIV and XXXV, Appendix.

† Bulletin No. 10, "Timber," U. S. Department of Agriculture, Division of Forestry.

found. From this it appears that the solids, such as albumen, gum, sugar, etc., contained in the sap, cannot exercise the influence on the strength of the wood that is sometimes claimed for them."

In all exogenous trees the wood next to the bark contains the most water and the center of the tree the least. In trees forming heart-wood the change from a moist to a driêr condition is usually quite abrupt at the sap-wood limit; thus in long-leaf pine the wood of the outer inch-thickness of the tree may contain 50 per cent of water, that of the next inch only 35 per cent and that of the heart-wood only 20 per cent.

Different trees, even of the same kind and from the same place, differ as to the amount of water they contain. A thrifty tree contains more water than a stunted one, and a young tree more than an old one; while the wood of all trees varies with the season of the year in its moisture-relations. In the living tree of certain species and at certain seasons, the sap will flow when the tree is tapped; but from boards, timber, etc., the water does not flow out under normal conditions, but must be evaporated. When the tree contains clefts or shakes, water will sometimes flow from them when the tree is sawed into lumber. From every sappy wood, water is forced out whenever the wood is warmed.

Before the living wood can be made suitable for building or other mechanical purposes most of the moisture which it contains must be eliminated. If the sap is not expelled or dried up it putrefies and causes decay. After a tree is cut, if left in a dry place, the moisture will gradually evaporate; and as this takes place the wood shrinks and often cracks. Hence it is desirable that the wood should shrink all it is going to before it is put into a building or piece of furniture.

3. SEASONING AND DRYING OF TIMBER.

12. AIR-SEASONING OR NATURAL SEASONING. Seasoning is simply evaporating the sap and moisture contained in the green wood, either by natural or artificial means. The drier the timber the less likely it is to decay or shrink.

After a log is converted into lumber, the boards, planks or timbers are "stacked" in the lumber-yard in a dry place under cover. In building the stacks the pieces are laid in courses or layers, usually about 6 feet wide, and 1-inch strips are placed between the layers so that the air will circulate through the stack. The lower layer should be at least 2 feet above the ground. Fig. 9 shows a well-built pile of tupelo, with a five-section foundation and five series of cross-strips. It requires a long time for wood to season in the open air, and it

never becomes sufficiently dry to answer for fine interior finishing or for furniture.

Framing-timber, however, is seldom dried in any other way, and as it is not often allowed to stay in the yard for more than three or four months, most of it used in the frame, floors and partitions of ordinary buildings is generally comparatively green, the seasoning being completed in the building. It is the shrinkage of lumber due to this final seasoning that causes most of the cracks in the interior of buildings having wooden floors and partitions. To prevent these

Fig. 9. Well-Built Lumber-Pile.

cracks it is generally desirable that a building should be commenced in the spring, so that its frame may season during the warm, dry weather of summer.

Sometimes, in the natural seasoning-process, the wood is immersed in water for about two weeks and then dried as in the air-process. This immersing in water removes the soluble substances in the sap-wood and the timber is less liable to crack or warp; but the heart-wood becomes brittle and loses its elasticity. If immersed too long the wood will become "brashy" on exposure to the air.

For special cases in which well-seasoned lumber is very desirable,

as in truss-timbers or beams supporting brickwork, a search through the lumber-yards will sometimes result in finding a few pieces that have been seasoning for several years. Some railway corporations and large manufacturing concerns keep a stock of lumber constantly on hand, so that it may remain in the stack several years before using.

13. KILN-DRYING. As it is impossible to season wood by natural means so that it will not shrink when put in a building that is to be kept warm and dry, it is necessary to dry by artificial means

Fig. 10. Method of Piling on a Truck Lumber to be run into Kiln.

all lumber that is to be used for finishing or in the manufacture of furniture. For this purpose a tight chamber called a "dry-kiln" is constructed, and a constant current of air heated from 150° to 180° Fahr. is made to pass over the lumber. Fig 10 shows the method of piling lumber upon the truck before it is run into the kiln. The piling should be as open as economical operation will permit.

Pine, spruce, cypress, cedar, etc., fresh from the saw, may be put in the kiln, allowing four days for 1-inch boards. Hardwoods, especially oak, ash, maple, birch and sycamore, should be air-seasoned

from three to six months to allow the first shrinkage to take place gradually before it is put in the kiln; and, for 1-inch lumber, they should then be exposed to the above temperatures for from six to ten days. The steaming of lumber is often resorted to in order to prevent checking and case-hardening, and also to make it bend more easily when bent pieces are required.

"The rapidity with which water is evaporated, that is, the 'rate of drying,' depends upon the size and shape of the piece and upon the structure of the wood. A board 1 inch thick dries more than four times as rapidly as a 4-inch plank and more than twenty times as rapidly as a 10-inch timber. White pine dries faster than oak. Water evaporates faster from a cross-section than from a longitudinal section and twice as fast from a radial section as from a tangential section."

Dry wood when soaked in water soon regains its original volume, and wood that has been kiln-dried at once takes up water from the air, even in the dryest weather; hence the necessity of having the building dry before delivering the finishing-lumber and of keeping it dry thereafter. This tendency of wood to absorb moisture may be lessened by boiling and steaming it and also by exposing it in dry air for a short time to a temperature of 300° Fahr.; but it cannot be entirely overcome.

14. CASE-HARDENING. When rapidly dried in a kiln, oak and other hardwoods "case-harden"; that is, the outer part dries and shrinks before the interior parts have a chance to do the same. Thus there is formed a firm shell or "case" of shrunken and, usually, checked wood around the interior. This shell does not prevent the interior from drying; but when this drying takes place the interior is commonly checked along the medullary rays, as shown in Fig. 11. In practice this result can be prevented by steaming the lumber in a kiln, or, still better, by drying it in the open air or in a shed before placing it in a kiln. Since the first shrinkage only is apt to check the wood, any kind of lumber which has once been air-dried, from three to six months for 1-inch stuff, may be subjected to kiln-heat without any danger.

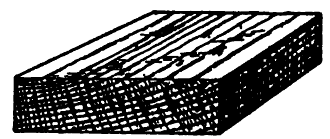


Fig. 11. Honeycombed Board. The checks or cracks form along the pith-rays.

15. MEASURE OF DRYNESS. The only reliable measure of dryness is that of weight. Professor J. B. Johnson, engineer in charge of various timber-tests made by the United States Government, offered the following recommendation, which appears to have much practical value:

"It would be well for architects to specify definite maximum percentages of moisture which would be allowed in lumber to be used in various kinds of interior finishing-work instead of the usual specification of 'thoroughly-seasoned lumber' or 'kiln-dried lumber.' As such terms as these usually have to be interpreted by the judgment of different individuals, and as the legal determination of the fact always rests upon the testimony of various witnesses, each having his own interpretation of the meaning of such terms, it follows that the standards so established are extremely indefinite and unsatisfactory. *If the architect would specify a particular percentage of moisture* for flooring, for instance, by saying that it should not contain more than 10 per cent of its weight in water, this would be a specification which would be perfectly definite and the fulfillment of which is easily determined. Thus, when flooring is delivered at a building, the architect may select a half-dozen flooring-boards from the lot, cut sections about 1 foot long from their central portions, take them to the nearest grocery or drug-store and have them carefully weighed. He can then dry them out by putting them into an ordinary cook-stove oven and keeping them there for a few hours at a temperature somewhat higher than that of the boiling-point. He can then weigh them again, quickly, before they have re-absorbed atmospheric moisture, wrapping them up carefully if it is necessary to carry them any distance for the purpose of weighing. *The difference between the two weights, divided by the dry weight gives the percentage of moisture* in terms of the dry weight. Thus, if a piece weighs 44 ounces when first weighed and 40 ounces when taken from the oven, the amount of moisture would be $4 \div 40 = .10$ or 10 per cent."

Since the moisture in the air in inhabited buildings is rarely less than 10 per cent, this may be taken as the standard moisture for "thoroughly seasoned lumber." Twelve per cent of moisture would probably not be detrimental, and in buildings that are not warmed above 68° Fahr. even 15 per cent may be allowed. As a check on the fulfillment of the specifications, kiln-dried lumber should be tested for moisture immediately upon its delivery; for if a building is in the least damp the lumber will quickly absorb additional moisture from the air. Framing-timber and timber for the outside finish may be considered well-seasoned when it contains only 15 per cent of moisture.

16. SHRINKAGE OF WOOD. 1. *The Cause of Shrinkage.* When a short piece of wood fiber, such as that shown in Fig. 12, is dried, it shrinks; its walls grow thinner, as indicated by the dotted lines; its width, *a b,* becomes smaller and the cavity larger; but the height or length *b c,* remains the same. The thinner the walls of the fiber the less, also, is the shrinkage. The end walls of the fibers, also, shrink in the same manner as the sides; but as the length is often a hundred or more times as great as the diameter, the effect of the longitudinal shrinkage is inappreciable.

A thin cross-section of several fibers shrinks in the same way, the walls of each fiber becoming thinner and the whole piece contracting in proportion. When the cells are similar in size and thickness the piece shrinks by about the same amount on all sides; but if the piece is made up of fibers, some with thin and others with thick walls, then as the row of thick-walled cells shrinks much more than the row of thin-walled cells, the piece becomes unevenly shrunk or warped, as shown in Fig. 13. Not only is the wood warped, but the force causing this warping continues to stress the interior parts of the piece in different directions.

Since in all our woods, cells with thick walls and cells with thin walls are more or less intermixed, and especially since the spring-wood and summer-wood nearly always differ in this respect, stresses and tendencies to warp are always present when wood dries out. The pith or medullary rays, also, have a marked effect upon the shrinkage of wood.

Fig. 12. Wood Fiber, Magnified.

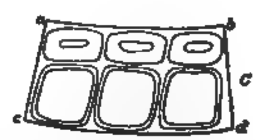


Fig. 13. Warping of Wood.

As was shown (Art. 2), the cells of the pith-rays have their length at right-angles to the direction of the wood fibers; hence, as the pith-rays dry they pull on the longitudinal fibers and tend to shorten them, and, being resisted by the rigidity of the latter, they are greatly stressed. The fibers shrink also at right-angles to the pith-rays, and the latter in resisting this, prevent the former from shrinking as much as they otherwise would. Thus the structure is subjected to two severe stresses at right-angles to each other; and it is principally owing to these stresses that whenever the wood dries rapidly the pith-rays separate, causing checks, which, whether visible or not, decrease the value and efficiency of the wood. The contraction of the pith-rays parallel to the length of boards is probably one of the causes of the small amount of longitudinal shrinkage which has been observed in them; but this longitudinal shrinkage is so slight that in practice it is customary to assume that the length of a timber is not affected by it.

2. *The Effect of Shrinkage.* Owing to the resistance to shrinking in the fibers in a radial direction due to the pith-rays, all woods

shrink more in a tangential direction, or around the rings, than in a radial direction; and this greater tangential shrinkage affects every phase of woodworking.

Fig. 14 illustrates the formation of checks in the end of a thick wood plank. As the plank loses water from its ends faster than from its sides the ends shrink more rapidly than the interior parts. The width *A B*, in diagram *X*, may have shortened, as shown at *Y*, while at a short distance from the end, *c d*, the original width is still preserved. This should produce a bending of the parts toward the center of the piece, as shown in exaggeration in diagram *Y*; but the rigidity of the several parts of the timber prevents such bending and the consequent stress leads to their separation as shown in diagram *Z*, the end surface of the timber being "checked." As the timber dries out, the line *c d* becomes shorter, the parts 1 to 6 are allowed to approach again and the checks close up and are no longer visible. The faster the drying at the surface, the greater the difference in the moisture of the different parts; and hence, also, the greater the stresses and consequently the amount of checking. This becomes very evident when fresh wood is placed in the sun, and still more evident when it is placed in a hot kiln. While most of these smaller checks are thus only temporary and close up again, some large radial checks remain and grow even larger as the drying progresses. The temporary checks not only appear at the ends, but are developed on the sides also, only in smaller numbers. They become especially annoying on the surface of thick planks of the hardwoods and also on peeled logs which are exposed to the sun.

X

Y

Z

Fig. 14. Formation of Checks in End of Thick Plank.

In the above discussion the wood has been considered as if made up of parallel fibers only, placed longitudinally in the log. This, however, is not the case. A large part of the wood is formed by the medullary or pith-rays. In pine over 15,000 of these occur on a square inch of a tangential section, and even in oak the very large rays, which are readily visible to the eye, represent scarcely a hundredth part of the number which the microscope reveals.

The effect of seasoning upon a log is shown in Fig. 15, *A*. The external portions of the wood shrink the most and the heart-wood the least, the wood splitting from the center in radial lines parallel to the medullary rays, but maintaining its original diameter. When sawed in half, a log shrinks as shown in *B*, and the boards sawed from it in the usual way take the forms shown in *D*, owing to the relatively greater tangential shrinkage of the wood.

Fig. 15. Effects of Shrinkage.

If a log is cut into four timbers, having square cross-sections, one edge of each being in the center, each will shrink to the shape shown in Fig 16. It will be seen that in this case the one diagonal, *d c*, of the cross-section remains unchanged, while the thickness of the timber each way is less than before and the four angles are no longer right-angles. Timbers sawed in this way, however, are much less liable to check than when sawed as in Fig. 15, *C*. Timbers sawed as in Fig. 16 are known as "quarter-sawed." A cylindrical shaft turned from a quartered timber before the latter is seasoned will shrink as shown in Fig. 17.

There is a great difference, also, in the effects of shrinkage upon different woods. The softwoods, such as pine, spruce, cypress, redwood, etc., having a comparatively regular structure, dry and shrink evenly and change their form much less than is the case with the hardwoods. Among the latter, oak is the most difficult to dry without injury. Small-sized split-ware and quarter-sawed boards season better than ordinary boards and planks. All high-grade stock is

c

d

Fig. 16. Shrinkage in Quartered Timbers.

Fig. 17. Shrinkage in Cylinders cut from Quartered Timbers.

carefully seasoned before manufacture in order to avoid warping and checking. When boards or planks which have shrunk to a

curved form are used to form flat boards, they should be sawed lengthwise into strips and glued together, the alternate strips being reversed as in Fig. 18. In this way the curvature in each piece becomes very slight, and the reversal of each acts as a check upon the shrinkage of its neighbors.

Fig. 18. Reversal of Boards to Counteract Shrinkage.

In constructing fine cabinet-work large and thick pieces of wood are usually avoided; but if required they should be made up of a number of thin pieces glued together. Large surfaces are generally made in panels or of smaller pieces covered with veneer.

Large timbers, when used for posts, are less liable to check if a 1-inch or 1½-inch hole is bored longitudinally through them. This hole should be connected with the outer air by ½-inch holes bored through transversely near the top and bottom. The tendency in large wooden beams and girders to twist and check may be largely prevented by cutting them into halves through the heart of the log and bolting the two pieces together with the heart-sides outward, as shown in Fig. 19.

Although it is the first shrinkage alone that tends to check wood, repeated swellings due to changes of moisture are apt to aggravate the bad effects of the first seasoning; so that wood should always be protected from moisture when once it has been dried. Wood which has been steamed bends more easily, and wood bent before seasoning and kept in position until seasoned, retains its bent shape and offers marked resistance to forces tending to straighten it.

3. *The Amount of Shrinkage.* The shrinkage of wood varies in different species and even in different parts of the same tree; hence any figures given for this shrinkage must be regarded as mere approximations. Sap-wood, as a rule, shrinks more than heart-wood of the same weight, but very heavy heart-wood may shrink more than lighter sap-wood. Quarter-sawed boards shrink less in width but more in thickness than those that are bastard-sawed.

Fig. 19. Halving of Timbers to Prevent Twisting and Checking.

The following table,* to which the woods of old oaks and of black locust have been added, is probably as reliable as any data that can be given:

* Bulletin No. 10, "Timber," U. S. Department of Agriculture, Division of Forestry.

TABLE II.

APPROXIMATE SHRINKAGE OF A BOARD OR SET OF BOARDS, 100 INCHES WIDE, DRYING IN THE OPEN AIR.

Variety of Wood.	Shrinkage.
	Inches.
All light conifers (soft pine, spruce, cedar, cypress)	3
Heavy conifers (hard pine, tamarack), honey locust, box elder, wood of old oaks,	4
Ash, elm, walnut, poplar, maple, beech, sycamore, cherry, black locust	5
Basswood, birch, chestnut, horse chestnut, blue beech, young locust	6
Hickory, young oak (especially red oak)	Up to 10

4. DEFECTS IN TIMBER.

17. SHAKES, KNOTS AND OTHER DEFECTS. 1. *Shakes.* When large trees are converted into timber, parts of boards or planks sometimes separate from each other and become two pieces, and occasionally the wood is so "shaky" that it is useless for building purposes. This separation of the wood is due to "shakes" which are formed in the living tree.

Shakes are of two kinds: A. "heart-shakes" or "star-shakes," which are splits or clefts occurring in the center of the tree, as shown in Fig. 20. They are common in nearly every kind of tree, but unless the cracks are very large they do no great harm. B. "cup-shakes" or cracks separating one layer from another, as shown in Fig. 21. It has been commonly supposed that the cup-shakes are produced by the wrenching of the tree during heavy windstorms, but a recent English writer believes that these, and also the heart-shakes, are produced by the expanding of the sap-wood. Cup-shakes often injure oak, hard pine, mahogany, walnut and elm, and are the chief defects in hemlock timber. Trees less than 10 inches in diameter are not subject to shakes. A "through-shake" extends through, between two faces of a timber.

Fig. 20. Heart-Shakes or Star-Shakes.

2. *Knots.* The weakening effect of a knot is about equal in tension and compression. Large knots, therefore, should be regarded as sufficient cause for the rejection of timber columns as well as of timber beams.

Knots are classified as follows: "sound," solid across the face, as

hard as the wood around it, and so fixed by growth as to remain solid; "loose," not held firmly in place by growth; "encased," surrounded wholly or in part by pitch or bark; "rotten," not as hard as the wood around it; "standard," sound, and not over 1½ inches in diameter; "large," sound, over 1½ inches in diameter; "spike," sawed in a lengthwise direction. (See Art. 27.)

Fig. 21. Cup-Shakes.

3. *Pitch-pockets.* These are cracks or openings in the grain of the wood containing pitch or bark in varying quantities. They are divided into three classes, as follows: "Small," not over ⅛ of an inch wide; "standard," not over ⅜ of an inch wide or over 3 inches long; "large," larger than standard size. A well-defined accumulation of pitch at one point in the piece is called a "pitch-streak."

5. CONVERSION OF TIMBER.

18. BASTARD-SAWED LUMBER. Sawed timbers should be sound, square-edged and straight, of standard sizes, close-grained and free from defects such as decay, shakes, cross-grain, unsound knots or knots in groups. Rough-sawed timbers should not be less than ¼ of an inch below standard size and standard-dressed timber not less than ½ an inch below the size specified. All boards and planks, except those intended for flooring, furniture or fine interior finish, are sawed from the log by gang-saws or circular saws which cut it into slices, as shown in Fig. 22. The edges are then trimmed by a circular saw, the edgings being worked up into laths or used for kindling-wood. Boards sawed from the log in this way are called "bastard-sawed." The faces of bastard-sawed boards, except a few cut from the center of the log, appear generally as shown in Fig. 2, and indicate the manner of sawing. About 25 per cent of the boards thus sawed come from near the center of the log

and show the annual rings running across the ends, as indicated on the cross-section; and the rings of spring-wood and summer-wood appear as parallel lines on the edges as shown on the radial section.

Fig. 22. Bastard-Sawed Lumber.

Fig. 23. Possibilities of Cutting Timber from a Log with Reference to Position of Grain.

Such boards are commonly called "quarter-sawed,"* and in some mills quarter-sawed boards are obtained by selecting out these pieces. Figure 23 represents the various methods of sawing timber from the log with reference to the position of the grain. The strength of a beam, column or plank varies in accordance with the manner in which it is cut from a log. This fact should be borne in mind by architects and engineers when selecting timber in which special strength is required. In *a b c d* and *p q u t* the center or pith or heart is about in the center; in *v w h j* or *r s t u* it is on one side; in *l m n o* it is in one corner; and in *e f g h*, *s j h t*, *w r u v*, etc., it is entirely outside. Figure 24 shows a method of sawing out heavy timbers from logs of soft-wood, such as pine, etc. Figure 25 shows what are known as "waney edges." These

Fig. 24. Method of Sawing Heavy Timbers from Soft-Wood Log.

Fig. 25. Waney Edges.

* "The expressions 'quarter-sawed,' 'rift-sawed,' 'vertical-grained,' 'straight-grained' and 'edge-grained,' as applied to manufactured wood, mean identically the same thing." *Northwestern Lumberman.* When the lines of summer-wood appear perfectly straight and parallel it is sometimes called "comb-grained."

are caused by a board being cut too near the surface of the log and thus including at its two outer corners portions of the bark of the tree.

19. QUARTER-SAWED LUMBER. Real quarter-sawed lumber is obtained by first quartering a log and then sawing up each quarter through planes making an angle of 45 degrees with the planes of the quartering cuts, as shown in Fig. 26. In this way there is but little waste; the width of most of the boards cuts at right-angles the circumference of the annual rings; and the saw-cuts often split the medullary rays, making a handsome silver grain, as in quartered oak and sycamore. It is more trouble and takes more time to saw lumber in this way, there is a little more waste and quarter-sawed lumber, accordingly, costs more than that which is bastard-sawed; but there are certain advantages in its use which more than compensate for its extra cost. Fig. 27 shows several methods of cutting hard-wood boards from the log. After a log has been cut into quarters, either of the methods 1, 2 or 3, may be used to display the silver grain of oak. Method 4 may be used to saw out

Fig. 26. Quarter-Sawed Lumber.

Fig. 27. Method of Cutting Boards from a Hard-Wood Log.

Fig. 28. Ideal Method of Sawing Floor-Boards from the Log.

thick boards for construction purposes. Fig. 28 shows an ideal method of sawing floor-boards, the boards being cut as shown and numbered 1, 2 and 3, and the remainder of the log being used for other purposes. The boards should be sawed as nearly as possible

in a radial direction from the center of the log. (See Art. 60, under "White Oak.")

At the present time hard pine and Douglas fir are the only soft-woods that are quarter-sawed; and these woods are not so cut when used for clapboards. The quarter-sawed product of these woods is employed almost exclusively for flooring and ship-decking.

Oak for flooring and finishing purposes is generally quarter-sawed, and many of the other hardwoods are sawed in this way.

Quarter-sawed lumber wears better, warps and shrinks less and in most hardwoods has a finer appearance than that which is bastard-sawed.

The best furniture is now made of quarter-sawed lumber and the finest finishing and best clapboarding and flooring is quarter-sawed.

Framing timber, such as planks and dimension-lumber, when intended for building purposes, is almost invariably bastard-sawed. For railroad ties and the construction of cars and carts, the lumber is often sawed by first quartering a log and then squaring the quarters, so that one edge of each piece is from the heart of the wood. This is done to prevent checking and warping. Many manufacturers of cars, carts and agricultural implements are now using Douglas fir for their products, owing to its great strength, lightness and low cost.

20. MERCHANT-SIZES OF LUMBER. With a few exceptions framing-timber is sawed to even dimensions and lengths, such as 4 by 6, 6 by 8, 10 by 12 inches, etc.

Floor-joists and planks are sawed 2, 3 and 4 inches thick, and 14-inch joists are usually sawed also to a 2½-inch thickness. A few mills saw 15-inch joists, and in New England 2 by 5-inch studding and 2 by 7-inch rafters are common; but in the West odd widths are not generally carried in stock.

Outside and inside-finishing woods of the common kinds are usually sawed 1, 1¼, 1½, 2 and in some woods, such as white pine and poplar, 2½ and 3 inches thick. Flooring is usually sawed 1 and 1¼ inches thick, so as to finish 13/16 and 1 3/32 inches. Ceiling or "matched sheathing," as it is called in New England, is sawed to a nominal thickness of ⅜, ½, ⅝ and ¾ of an inch. The actual finished thickness is in each case 1/16 of an inch less.

The more expensive finishing woods are generally used in ⅝ and ¾-inch boards and are also used in veneers. (See, also, Arts. 22, 78 and 79.)

21. SHORT AND ODD LENGTHS OF LUMBER. The great waste of material in ordinary lumber-manufacturing, because short and odd lengths and widths are not used, has been blamed

mainly on the lumberman. The truth is, however, that the lumberman is practically helpless. He can find a paying market only for the lumber cut from logs of the regulation length called for by builders and architects. If specifications were drawn for the sizes actually used the shorter logs would be in demand and the waste due to this cause would be saved.

This fact was brought out in connection with the study of forest-utilization made by the Forest Service for the National Conservation Commission. One of the schedules of inquiry sent to lumber-manufacturers contained a query as to the extent to which more careful specifications of material might reduce waste. Replies to this query showed that in some cases as much as 25 per cent of the felled trees were never hauled from the woods, simply because specifications cling to conventional lengths. Thus, lumber which is to be used in lengths of from 1 to 6 feet, is frequently ordered in long lengths, and yet the short lengths which would exactly and economically meet the requirements cannot be sold.

The case of beveled siding illustrates this. "I have just seen a book," wrote the secretary of a prominent Pacific Coast association, "containing about two hundred designs of houses, and in all of these designs, I believe that 90 per cent of the siding is under six feet in length. At the same time the contractor will order lengths of from 12 to 16 feet in order to build them."

It has always been the custom in this country to sell lumber in even lengths only, and the prices on lengths under 10 feet in almost any material, are from $2 to $10 per thousand less than for lengths over 10 feet. In cutting any kind of finished product, such as flooring, ceiling, beveled siding, etc., so as to grade the lumber in an economical manner, there is bound to be from 5 to 10 per cent of the lengths which are under 10 feet. It is the rule with most manufacturers to burn up all boards under six feet in length, as there is absolutely no sale for them. On the other hand the architect and the contractor order their lumber in long pieces with the idea of [illegible] up into lengths of from 1 to 6 feet when placing them [illegible]

[illegible] writer says that 10 or 20-foot lengths are commonly [illegible] the flooring of porches which are only 5 feet wide. He [illegible] by making the following estimate of the waste resulting [illegible] practice, in building specifications, of disregarding the [illegible] of waste.

[illegible] the waste in our timber products from this one cause, which [illegible] prohibits a man from going to the expense of taking [illegible] any timber he might cut into these shorter lengths and find [illegible], and which gives him no market for shorter lengths resulting

from the ordinary manufacture of logs into long lengths, will easily run as high as 25 per cent of the timber on any section of land."

It would be a great mistake to charge such waste as this to any voluntary device on the part of lumbermen, who waste only what they cannot use in their business. The closer drawing of specifications, a better knowledge of the timber-situation, and a recognition of the possible uses of short lengths of lumber will not only increase the profits of the lumbermen but greatly prolong the duration of the lumber-supply.

22. MEASUREMENTS OF LUMBER. The term "lumber" includes all material sawed from logs for structural or other commercial purposes. In the trade, the term "timber" is applied to pieces of large size, such as joists, beams and girders.

What Americans call a "lumber-dealer" is known in England as a "timber-merchant." The term "timber," in New England, is applied to trees large enough to be cut into logs for the mill, to the logs entire and to the large single sticks into which they are hewed or sawed. When the logs are cut into boards, planks, joists and so on, they form "lumber." In the West, timber is generally understood to mean standing trees, and includes all trees, large and small, without reference to their fitness for the mill. The cutting and hauling of this timber is known there as "lumbering"; but in a large part of New England it is called "logging." What are in some quarters known as "joists" are elsewhere called "scantlings," and what Americans call "boards" or "planks" the English call "deals." In this country a person who "splits out" shingles is called a "shingle-weaver." In England shingles are not made in that way; but laths are regularly "riven," and a maker of laths is called a "lath-render."

Lumber is resawed to obtain the smaller sizes. "Dressed lumber" is resawed lumber planed at the mill and may be had in many dimensions suitable for all uses. "Dressed" boards and planks are called "clear" when free from all defects, such as knots, checks, etc., and may be procured in regular sizes, from 5/8 to 1 7/8 inches thick, in each case 1/8 of an inch less in thickness than that of the sawed lumber. Lumber sawed on four sides is termed "resawed lumber." Lumber sawed on two sides only is termed "rough-edge" or "flitch." Framing-timber, planks and boards are always sold by "board-measure," that is, the number of superficial feet the piece would contain if sawed into boards 1 inch thick. Matched flooring and ceiling are measured by the size of the boards from which they are worked.

Boards less than 1 inch in thickness are measured by the square foot, the price depending upon the thickness. Veneers are al-

ways sold by the square foot. Lattice and moldings are sold by the lineal foot, but the price of the latter depends upon the thickness as well as upon the width. Laths, shingles and clapboards are sold by the thousand.

Lumber of all kinds generally comes from the mill in even-foot lengths, as 10, 12, 14, 16, etc. feet, and lengths between these measurements are "cut to waste." (See, also, Art. 20 for merchant-sizes of lumber, and Arts. 78 and 79.)

23. INSPECTION OF TIMBER. The dimensions and quality of the stock are taken into account when inspections are made. Condemned pieces are plainly marked with branding-irons or paint.

The strongest and most durable timbers are obtained from the slow-growing trees, from those with narrow, annular rings and from those with small amounts of sap or resin in their pores. Timbers cut from the heart-wood and containing no sap-wood are the strongest. The wood should contain no shakes, flaws, large knots, dead knots, nor blemishes and should be straight in fiber and uniform in substance. A sound timber when freshly cut should show a bright, firm surface with a silk-like luster when planed and should emit a sweet odor. Dark shades in woods of naturally strong color generally indicate durability and strength. The surface of a freshly cut timber should never be "woolly," nor clog the teeth of the saw when cut. Decaying timber gives a dull sound when struck, while sound timber is sonorous. A disagreeable odor or dull, chalky appearance are indications of bad timber. Good, sound timber transmits faint sounds from one end to the other up to a distance of fifty feet. If no outer signs of decay or rot are in evidence, they may be detected by boring into the timber and examining the odor and appearance of the wood-dust.

6. STRENGTH OF TIMBER AS AFFECTED BY ITS PHYSICAL CONDITION.

24. GENERAL CONDITIONS. The methods of calculating the strength of timber under the different kinds of stresses to which it is subjected are fully explained in Kidder's "Architects' and Builders' Pocket-Book," and will not be considered here. There are, however, certain variable conditions in timber which it is impossible to recognize in formulas, but which often need to be taken into account when it is desired to utilize the maximum strength of the wood. These conditions are not generally explained in the handbooks, and may appropriately be considered in a work of this character.

25. EFFECTS OF MOISTURE ON TIMBER. In some of the "United States Timber-Tests" on long-leaf yellow pine, an

actual moisture-determination was made for every test of strength. Most of the tests, also, were made either in pairs or in sets of three, the wood for each set being taken from the same tree and as nearly identical as possible, except that one piece was tested while green and another after it was seasoned. These tests were numerous and thorough and seemed to indicate that all kinds of timber are about twice as strong when thoroughly seasoned as they are in a green state. It was shown, also, that the maximum strength accompanies a 5 or 6 percentage of moisture by weight, the strength at absolute dryness being somewhat reduced. Additional notes relating to the weight of timber are given in the following article.

It is stated,* however, that with large timbers in commercial use it is not safe to count upon any greater strength, even after seasoning, than that of the timbers in the green condition, although with very small, perfect stock, in sizes up to about 4 by 4 inches in cross-section, ordinary air-drying may be counted upon to increase the strength from 50 to 150 per cent.

The moisture in fairly-well-seasoned timber is about 15 per cent, by weight.

26. WEIGHT OF TIMBER. For any given species of timber, and for any given degree of dryness, the strength is almost directly proportional to the weight. This is considered to be due to the fact that the weight, for the same percentage of moisture, indicates the density and consequently the proportionate number of fibers; and that the wood which has the most fibers is naturally supposed to have the greatest strength.

The strongest portion of a young tree is the heart. The strongest portion of a very old tree is about midway between the heart and the sap-wood. The upper part of a tree, also, is slightly weaker than the lower part.

27. KNOTS AND CROSS-GRAIN IN TIMBER. The weakening effects of knots and cross-grain is about the same in compression as in tension. Large knots especially should be regarded as sufficient cause for the rejection of timber columns as well as for the rejection of timber beams. (See Art. 17.) The best single test of timber is the test of a short column or the endwise crushing-test. It is probable that timber does not usually lose its strength from age or use alone, although it is well known that little more than one-half the breaking-load of a beam, if left on it continuously, will ultimately break it. Rigid inspection should be given to all structural timber, as the defects found in it strongly affect its strength. (See Art. 23.)

* See Circular No. 108, U. S. Department of Agriculture, Division of Forestry.

7. SELECTION OF TIMBER FOR SPECIAL PURPOSES.

28. GENERAL PRACTICE. In selecting wood or timber for a special use, that species should be chosen which appears to meet most fully the particular requirements of the case. Thus, for framing-timbers, woods that are abundant and consequently cheap and which can be obtained in large dimensions, are generally chosen, although in some instances extra strength and durability are more important considerations.

For outside finishing, ease of working and freedom from warping and checking are the principal requirements. The wood selected should stand the wear resulting from exposure.

For wood that is to be buried in the ground, in whole or in part, or to be used for piling, durability is the chief consideration, although the question of cost must often be considered.

For floors, the wearing-quality is the main consideration, while for fine, interior finishing and cabinet-work the color and grain of the wood generally control the choice.

The following list indicates those woods which are usually considered best adapted to the particular requirements met with in building-construction and finishing:

For light framing, dwellings, tenement-houses, etc.: Douglas fir (Oregon pine), spruce, short-leaf yellow pine, Norway pine (red pine) and hemlock are the woods generally used.

For posts, girders, truss-timbers and heavy framing: long-leaf yellow pine (Georgia pine), Douglas fir or white oak are to be preferred. Next to these are the short-leaf yellow pine and the best qualities of spruce.

For very long truss-timbers, flagstaffs, etc.: Douglas fir and long-leaf yellow pine are the only available woods. Good-sized timbers of the former can be obtained up to 120 feet in length.

For outside finish: White pine, Douglas fir, larch, white cedar, redwood or cypress should be used.

For shingles: Cedar, cypress, white pine and redwood.

For siding and clapboards: Cedar, larch, Douglas fir, redwood, cypress and white pine are the best woods. Douglas fir gives general satisfaction throughout the western and middle states and is rapidly finding favor in the East. The western white spruce is soft, does not warp, stretch or shrink and makes very good siding.

For posts and sleepers set in the ground: White cedar, pitch pine,* chestnut, redwood, cypress, black locust and Douglas fir.

For piles and cribbage or grillage: Oak, elm, long-leaf yellow pine, Douglas fir, Norway pine, cypress, spruce, white pine and hemlock, in the order given. The first four only should be used in salt water.

* A very resinous variety of the hard pines growing along the Atlantic coast from Canada to Georgia and in Kentucky.

For sashes, solid doors, bases for veneers and all joiners' work that is to be painted: Clear white pine, now grown scarce and expensive, has generally given the best satisfaction, although poplar (whitewood) is often used for reasons of economy. Cypress, also, is well-adapted for sashes and solid doors. Douglas fir is coming extensively into use for these purposes, doors, solid and veneered, being made of it. Western white pine, Douglas fir and larch, also, are being used by sash-manufacturers, as clear, eastern white pine is rapidly disappearing.

For thresholds and floors, or wherever hardness and resistance to wearing is required: White oak, maple, long-leaf yellow pine or Douglas fir, all quarter-sawed.

For linen-chests and linen-closets: Florida, western or Alabama red cedar.

For inside finish: Redwood, cypress, Douglas fir, larch and white pine and any of the hardwoods are suitable. Both larch and Douglas fir are soft and easy to work and make an attractive finish. They are generally selected to please the especial taste of the owner and all are sufficiently durable. Every hardwood needs to be thoroughly seasoned and kiln-dried, and all hardwood doors or sashes should have pine cores, covered with a $\frac{3}{16}$-inch veneer of hardwood. (*For the Pacific Coast practice, see the following article.*)

29. PACIFIC-COAST PRACTICE.*

For framing, studs, joists, posts and girders: Douglas fir.

For outside finish: Redwood, cedar, or Douglas fir. It should be noted that redwood blackens with age and exposure.

For shingles: Cedar is used where the darkening of redwood might prove objectionable. Redwood is, however, most common and makes excellent shingles. There is a demand, though small, for redwood "shakes."

For structures in contact with the ground: Redwood, invariably.

For sashes: Sugar pine and cedar.

For inside finish: Redwood, sugar pine or Douglas fir. Of hardwoods there are gum, jenisero and some koa and teak, all but the gum being imported from Hawaii or the Philippines.

For thresholds and floors: White oak, maple, Douglas fir and western hemlock. The first three are quarter-sawed.

For linen-chests and linen-closets: Red cedar, and Port Orford cedar. (*For general practice, see the preceding article.*)

8. DECAY AND PRESERVATION OF TIMBER.

30. DURABILITY OF TIMBER. One kind of wood, under certain conditions, is as durable as any other. When kept dry or entirely submerged in water it lasts indefinitely, but under other conditions it may decay very rapidly. The general causes of the deterioration, decay and gradual destruction of timber are the pres-

* This includes data furnished the editor by W. C. Hays, San Francisco, Cal., Whidden & Lewis, Portland, Ore., and Willatzen & Byrne, Seattle, Wash.

ence of sap, exposure to alternate moisture and dryness, exposure accompanied by heat, want of ventilation, bacteria, fungi, worms and insects.

Dryness and ventilation are the best preventatives of the decay of timber used in general construction; and wood kept dry has been known to last for centuries, although it has finally become brittle and lost its strength. Water, also, seems to act as a preservative; and some kinds of timber, such as oak, elm, birch and elder, constantly immersed in still water, may last for an indefinite period. Piles and the cribbage or grillage resting on them are about the only forms of building-construction subject to these conditions, and it is essential to their preservation that they be placed entirely below the low-water line, as nothing causes decay so rapidly as alternations of moisture and dryness.

"Rot in timber is decomposition or putrefaction, which is generally occasioned by dampness and which proceeds by the emission of gases, chiefly carbonic acid and hydrogen.

"There are two kinds of rot to which the woodwork in buildings is subject, 'dry rot' and 'wet rot.' The chief difference between them seems to be that wet rot develops where the gases evolved can escape. By it the tissues of the wood, especially the sappy portions, are decomposed. Dry rot, on the contrary, occurs in confined places where the gases cannot escape, but enter into new combinations, forming fungi which feed upon and destroy the timber."

31. WET ROT IN TIMBER. This appears only when the wood is kept damp or is subject to alternate dryness and moisture; and it cannot take place if the wood is once thoroughly seasoned and the further absorption of moisture prevented. Wet rot communicates itself to the sound portions of wood by actual contact only, and if all the rotten wood is cut away and the balance of the timber kept dry, the wet rot will have no further affect.

32. DRY ROT IN TIMBER. This is generally caused by want of ventilation. Confined air, without much moisture, encourages the growth of a fungus, which eats into the timber, renders it brittle and so reduces the cohesion of the fibers that they are reduced to powder. It generally commences in the sap-wood.

"An excess of moisture prevents the growth of the fungus, but moderate warmth, combined with dampness and want of air, accelerates it. In the first stages of rottenness the timber swells and changes color, is often covered with fungus or moldiness and emits a musty smell."

"When the fungus first appears on the sides of timbers it covers the surface with a fine, delicate vegetation, called by shipwrights, 'mildew.' These fine shoots afterward collect together, and their appearance may then be compared to hoar frost. They increase rapidly, assuming gradually a more

compact form, like the external coat of a mushroom, but spread, in the form of leaves alike over woodwork, brickwork, stonework and plastering, being in extent larger or smaller, in proportion probably to the nutriment the wood affords. The colors of the fungus are various; sometimes white or grayish white, with violet, yellowish brown, or a deep shade of fine, rich brown." *

The parts in which dry rot is most likely to occur are those imbedded solidly in damp plaster or masonry, such as the ends of beams built into walls, bottoms of posts imbedded in concrete, sleepers bedded in damp mortar or concrete, beams surrounded solidly with fire-proof materials, beams in damp, close and imperfectly ventilated cellars, and wainscots or other finish fixed to damp walls. Anything which absorbs moisture and confines it in contact with wood, particularly if accompanied by heat, is likely to accelerate decay. Wet or unseasoned lumber, covered with paint, tar, plaster, or any material which prevents the moisture from drying out, is quite sure to be attacked by rot. Sap-wood, also, is more subject to decay than heart-wood, and doubly so where the latter is protected by resinous substances, as in pine and cedar.

Dry rot is especially dangerous, as it not only eats up the entire timber in which it originates, but the germs of the fungi producing it spread themselves to all adjacent woodwork whether or not the latter is in actual contact with the affected pieces. When dry rot is discovered, these affected pieces should be immediately removed, if possible, all adjoining woodwork thoroughly scraped and washed with strong acids and provisions made for thorough ventilation. If the rot is on the outside of the timber, and has not penetrated far, it may be scraped away and the timber treated with strong acids; and if ventilation is furnished the rot may be stopped. Fortunately dry rot is not very prevalent in our northern states, but in some of the southern states great caution has to be exercised to prevent it. (See, also, Art. 97.)

33. COMMON ROT IN TIMBER. This form of decay can be recognized by the presence of yellow spots on the ends of timbers or by yellow dust in the cracks and checks, especially if the pieces are in contact. Common rot is caused by poor ventilation in the sheds in which the timber is being air-seasoned.

34. WORMS WHICH DESTROY WOOD IN WATER. Among the little animals which destroy wood in water are the following:

(1) *The Limnoria or Gribble (Limnoria terebrans).* This is a crustacean which bears a resemblance to the wood-louse and is about the size of a rice-grain. Both water and air are necessary to

* "Notes on Building Construction," Part III. Rivington's South Kensington Series.

its life. It crawls, swims and jumps. It bores only to a depth of about ½ an inch, devouring the wood-substance with its mandibles, undermining the surface until it becomes brittle, causing the surface to be finally washed away by the waves and currents and leaving fresh surfaces for renewed attacks. It will destroy from one to three inches of wood per year. The limnoria always works in large colonies in both cold and warm waters, prefers siliceous shores, is generally most destructive at low-water mark in salty water and remains between the high and low-water levels.

(2) *The Lycoris fucata.* This is a small many-legged worm resembling the centipede, and living in the mud. It is a vigorous enemy of the teredo. It crawls up a pile, enters the hole made by the teredo, destroys the latter by devouring it, enlarges the entrance to the hole and makes the latter its home.

(3) *The Teredo (Teredo navalis).* The teredo or "shipworm" belongs to the mollusk-species, and is the most active of the worms which destroy wood. Its eggs, laid on submerged timber, soon hatch out small, rapidly growing worms, each with an auger-shaped shell-like substance on its head which enables it to bore into the wood, generally in the direction of the grain. In the process of boring the teredo lines the hole with a calcareous deposit, partly closes the outer end with small flaps or lids and gradually increases in size. It has been found up to ½ of an inch in diameter and varies from 15 inches to 6 feet in length. It is found only in salt water and prefers the warmer climates, although it is sometimes found in cold water. It works from half-tide level to ground-level, preferably in clear water and near calcareous shores.

35. METHODS OF PRESERVING TIMBER. For ordinary building-construction the best way to preserve timber from decay is to have it thoroughly seasoned and well ventilated, for if these conditions are secured there is little danger of rot.

For the majority of buildings designed by an architect it is practically impossible to obtain thoroughly seasoned lumber, but much can be done to secure ventilation; and as far as this is concerned large beams and girders last longer when built-up and cased, and posts last longer when bored longitudinally, as described in Art. 16. When built into masonry walls, a space for ventilation should be left around the ends of the timbers.

Wherever beams have to be enclosed air-tight, some means of ventilation should be provided if possible, particularly if the wood is not thoroughly seasoned or if there is any chance of its becoming damp. In all outside woodwork care should be taken to make the joints so as not to afford a lodgment for moisture. All woodwork exposed to the atmosphere is generally protected by paint or oil;

but these materials should not be applied while the wood is wet or damp, nor, if practicable to temporarily omit them, while it is green. All woodwork in contact with outside masonry should have its back surfaces painted.

Posts to be set in the ground should either be dipped in coal-tar or have the parts to be buried charred. Timber that is to be used in sea-water for wharfs and similar structures and for construction subject to moisture, but not constantly wet, such as piles and sleepers, should be impregnated with creosote under a pressure of from 30 to 40 pounds per square inch. There are several processes for preserving timber, briefly described in the following paragraphs; but the filling of the pores with creosote is admitted to be equal in efficiency to any, and for protecting wood against the teredo and other worms, it is at present admitted to be the best treatment.

The following are some of the best-known methods used for the preservation of timber:

Boucherie's Process. In Germany this process is much used, posts treated by it having a life of over 30 years. One pound of sulphate of copper to 8 to 12 gallons of water is applied to the timber under a pressure of 15 pounds per square inch. To be effective the timber should be subjected to this process not later than ten days after it is cut.

Burnett's Process or Burnettizing. This process consists in impregnating the timber with zinc chloride under pressure. The solution used consists of 43 per cent of zinc chloride, 55 per cent of water and 2 per cent of impurities, such as iron, lead, etc., and is heated to 150° Fahr. before use. This process is common in Europe and is coming into use in the United States in the treatment of railroad ties. The load of timber, or "charge" as it is called, is placed in a large retort made of metal and the doors bolted shut. Live steam at 20-pounds-per-square-inch pressure, is introduced into a 20-inch vacuum produced in the retort, continued about five hours and then blown off. The retort is then drained and after a second vacuum of from 22 to 26 inches has been formed, the zinc-chloride solution, under a pressure of from 120 to 150 pounds per square inch, is introduced and maintained until the required amount, about $^{24}/_{100}$ of a pound of zinc per cubic foot of wood, has been injected. From eight to twelve hours are required for the completion of the process, after which the surplus is drained off and the timber taken out. The ease of impregnation increases with the greenness of the timber.

Creosoting. While this process is one of the best for the preservation of timber and particularly from the ravages of the teredo or shipworm, its use is not practicable for the woods of interior trim and decorative work. Construction-timber to be treated is placed on small trucks or "bogies" and run into cylinders varying from 6 to 9 feet in diameter. Steam is then turned in and continued until all parts of the charge are thoroughly heated and the vaporizing of the sap effected, the time required varying from thirty minutes to several hours. A pump then removes the steam and sap

and causes a partial vacuum into which is turned distilled coal-tar or creosote-oil at a temperature of 160° Fahr., filling the cylinder. A pressure of from 150 to 200 pounds per square inch is maintained until the timber absorbs and retains about 5 pounds of oil per cubic foot, after which the surplus oil is drawn off and the charge removed. The entire process requires about twenty-four hours, from 12 to 18 pounds of oil per cubic foot being required for timber that is green and hard and a smaller amount for that which is well-seasoned.

Kyan's Process. Bichloride of mercury (corrosive sublimate) is used to impregnate the timber, the mixture used being one pound of the bichloride to six gallons (50 pounds) of water.

Payne's Process. The timber is placed in a vacuum and an injection of sulphate of iron is followed by one of sulphate of lime or soda-solution. The wood is made incombustible, also, by this process.

Seely's Process. This treatment, which is a modification of a creosote-process, involves the use of creosote-oil, which is placed in a tank and heated to a temperature of from 212 to 300° Fahr. The timber is immersed in it until the moisture in the wood is expelled, after which the hot oil is withdrawn and the timber subjected to a cold bath. The wood absorbs about 4 pounds of oil per cubic foot.

Thilmany's Process. This process consists in impregnating the wood with zinc or copper sulphate. Green wood generally gives the quickest results, requiring less steaming. The timber to be treated is placed on flat cars, run into the cylinders and steamed until the sap is driven out. The air and condensed moisture are then removed by an air-pump, causing a vacuum in the cylinder which is then filled with a solution of copper or zinc sulphate maintained at a pressure of from 80 to 100 pounds per square inch. The remaining solution is then removed and replaced by a one-per-cent solution of barium chloride under a similar pressure.

Vulcanizing. The timber is placed in a closed vessel under pressure to prevent the sap from vaporizing when subjected to heat, which is gradually increased to 400° Fahr. An increase of pressure, also, accompanies the increase in heat. The duration of the process is generally also, about eight hours for softwoods and from ten to twenty hours for hardwoods. For the vulcanizing of ordinary woods about 400° Fahr. is considered sufficient, and it results in making the sap in the cells undecomposable and insoluble.

Wellshouse's Process. In this process the timber is placed in a cylinder, steamed for from one to three hours and then saturated with a solution of glue and zinc chloride which is forced into the cylinder under pressure. This is followed by an injection of tannin, resulting in a combining of the tannic acid and the glue in the wood, and the precipitation of the same in the form of an insoluble compound. The zinc is retained by the wood and the excess-glue is precipitated by an excess of tannic acid added for this purpose.

Processes using creosote and zinc chloride, or a combination of the two as the preservative agents, are the ones commonly used in the United States.

"There are two principal methods of injecting the preservatives in common use into the timber. These may be called the 'pressure-cylinder' method and

the 'open-tank' method. A third process, known as the 'brush' method, is used to a more limited extent." *

9. VARIETIES OF TIMBER USED IN THE UNITED STATES. THEIR CHARACTERISTICS AND USES.†

36. GENERAL CLASSIFICATION .The woods used for building purposes may be divided into two general classes: A, the coniferous or needle-leaved woods and B, the broad-leaved woods.

Needle-leaved woods are characterized by a simple, uniform structure, the presence of resins and lighter weights. They are soft, stiff, abundant in large sizes and form the greater part of all lumber used. They are variously known as "needle-leaved woods," "soft-woods," "conifers" and "evergreens."

Broad-leaved woods are characterized by complex fiber-conditions, absence of resins and greater weights. Difficulty in working them increases in proportion to the complication of their structure. Most of them are deciduous, that is, shedding the leaves every season and they are variously known as "broad-leaved woods," "deciduous trees" and "hard-wood trees."

37. A. THE CONIFEROUS OR NEEDLE-LEAVED WOODS. These woods include nearly all of the soft woods and furnish nearly all of the framing-timber and the larger part of that used for finishing.

38. I. PINE. (*Pinus.*) The pine is used more extensively for building purposes than any other kind of wood; it is the principal wood in common carpentry and also in heavy construction. It usually grows to a great height, with a few branches and straight cylindrical stems, thus affording boards and timbers of considerable size and length. It also forms vast forests, which greatly facilitate cutting and shipping.

There are many varieties of pine used for building purposes, but the following only are used to any great extent:

39. 1. SOFT PINE. (1) *Eastern White Pine* (*Pinus strobus*). This is called, also, "soft pine." During the past thirty

* Bulletin No. 139, "A Primer of Wood-Preservation." United States Department of Agriculture.

† Much valuable data for this division of the subject has been obtained from "The Silva of North America," by Charles Sprague Sargent, Houghton, Mifflin & Co., Boston and New York, 1890-1905; the "Cyclopedia of American Horticulture," by L. H. Bailey, The Macmillan Co., New York, 1901; "The Principal Species of Wood," by Charles Henry Snow, John Wiley & Sons, New York, 1903; "Timber and Timber Trees," by Thomas Haslett and H. Marshall Ward, The Macmillan Co., New York, 1894; "The Treasury of Botany," by John Lindley and Thomas Moore, Longmans, Green & Co., New York, 1876; and from the various publications of the United States Department of Agriculture, Forest Service, and of the Department of Commerce and Labor, Bureau of the Census. (See, also, Arts. 28, 29, 78, 79, 168 and 235).

years it has been obtained principally from Michigan, Wisconsin and Minnesota. At an earlier period it was obtained from Pennsylvania and New York and still earlier the center of supply was New England. This tree was formerly the most important timber-tree of the Union, furnishing the best quality of soft pine. The supply has been so far exhausted that the wood is now used principally for finishing-purposes, as deck-material for small vessels, for fishing-dories, parts of furniture, and, in lessening quantities, for shingles.*

The second growth, however, in some regions is meeting a heavy demand.

"In Massachusetts, for example, the cut in 1908 was 238 million feet, and practically all of it was second-growth. It is not improbable that a similar cut can be made each year in the future from the natural growth of white pine in that state. It might be shown by a simple calculation that if one-tenth of the original white-pine region were kept in well-protected second-growth, like that in Massachusetts, it would yield annual crops successively for all time, as large as the white-pine cut in the United States in 1908. To do this would require the growth of only 25 cubic feet of wood per acre each year, and good white-pine growth will easily double that amount. The supply of white-pine lumber need never fail in this country, provided a moderate area is kept producing as a result of proper care." †

The wood, when of good quality, is creamy-white in color, soft, straight-grained, light in weight and very easily cut. It contains very little resin and is durable only in dry air. In transverse strength it is the weakest of all woods used in building, with the exceptions of hemlock and redwood. It also swells or shrinks seriously when the hygromètric state of the atmosphere changes greatly; but on the other hand it has the advantages of being free from knots and very easily worked. Its most valuable characteristic, however, is its freedom from warping and cracking in the process of seasoning. It probably stays in place, or "stands," better than any other wood and is the best to use for solid doors, sashes or light framing of any kind. It makes, also, the best base for veneered work, and is remarkably well adapted to the work of the patternmaker. When protected by paint, it is the best of all the northern woods for outside finish and is best adapted to all joiner's work that is to be painted. The best qualities are so

* The production of white-pine shingles in the United States in 1910 was 1.1 per cent of the total shingle-output. The red cedar of the Northwest and the white cedar of the Lake States furnished 77.9 per cent of the total production. Bureau of the Census, Department of Commerce and Labor, Forest Products Bulletin No. 2, "Lumber, Lath, and Shingles," 1910.

† "Uses of Commercial Woods in the United States." United States Department of Agriculture, Forest Service, Bulletin No. 99, 1911.

expensive, however, that whitewood and other woods are now often used as substitutes. The highest grades of white pine vary little in cost from mahogany, oak, or black walnut.

(2) *Sugar Pine (Pinus lambertiana).* A very large tree forming extensive forests with the balsam-fir in Oregon and California, and growing principally at heights of from 1,000 to 10,000 feet above sea-level. It much resembles the eastern white pine and is used for the same purposes, although its standing-qualities and working-qualities are not quite equal to those of the former. The wood is used for framing, interior finish, doors, blinds, sashes, etc.

(3) *Western White Pine* (*Pinus monticola*). This tree is known locally, also, as "soft pine," "silver pine," "white pine," "mountain pine" and by various other names. Its commercial range lies principally in Montana, Idaho, Washington, Oregon and California, the largest cut being from Idaho. It seldom grows alone, usually forming but a small part of the forests in which it is found. The wood is soft, not strong, light in weight and flexible. It has a fine, straight grain, is slightly resinous and is light brown or red in color with the sap-wood nearly white. The heart-wood is fairly durable in contact with the soil. Although the wood works as easily with tools as does eastern white pine, its stiffness surpasses that of the latter by 12 per cent and its weight is a little greater. It is used for many purposes, locally, but is principally in demand for distant markets.

Another variety of western white pine, the *Pinus flexilis,* forms mountain-forests of considerable extent in the Rocky Mountains from Montana to Mexico. It is used for general building purposes.

(4) *Pitch Pine* (*Pinus rigida*). This is found along the Atlantic coast from Canada to Georgia and is used for coarse lumber, flooring, door-frames, window-frames, mine-timbers and interior finish.

40. 2. HARD PINE. (1) *Norway Pine (Pinus resinosa).* This tree, known also as "red pine," "hard pine" and "Canadian red pine," has a commercial range which lies in Michigan, Minnesota and Wisconsin, and in the provinces of Canada. A small quantity is cut in New York, Pennsylvania and New England. It attains a height of from 70 to 125 feet, with a diameter of from 2 to 3 feet at the base, the trunk continuing of uniform diameter for two-thirds of its length. The following are the characteristics of this wood: Light in weight, not strong, moderately soft; grain rather coarse, even and straight; compact; annual rings rather wide; summer-wood not broad, light-colored, resinous; resin-passages few, small, not conspicuous; medullary rays few, thin; color

light red, sap-wood yellow or often almost white; readily worked with tools; not durable in the soil. Its strength is about equal to that of spruce and it is used principally for framing-timber.

(2) *Long-leaf Pine (Pinus palustris)*. Few woods have a greater number of names in different localities than this tree and this is the wood generally referred to when "yellow pine" or "Georgia pine" is specified. It is the most valuable of all the southern pines, both on account of its superior strength and durability and also on account of its large size, which enables very long timbers to be cut from it. This tree attains a height of from 55 to 100 feet and a diameter of from 1½ to 3 feet. The following are its chief characteristics: heavy, hard, very strong; tough; grain fine, even, straight; compact; annual rings narrow, especially in young and old growth; proportion of heart-wood large; very resinous, resin-passages numerous and large; medullary rays numerous, conspicuous; color light red or brown, the thin sap-wood light yellow; durable in contact with the soil. Though not so tough and elastic as white oak, the best long-leaf pine successfully rivals it in stiffness. "If a beam of each kind of timber, equal in dimensions, be supported at the ends, the oak beam will depart most from its 'mold,' but will break under about the same load."

This variety of pine is principally obtained from the southern Atlantic and Gulf States, that obtained from the latter being now considered the better timber. It is largely used throughout the Eastern and Middle States for heavy framing-timbers. Only one other timber in the United States at present (1913) stands on an equal footing with long-leaf pine in heavy construction, such as beams, girders, sills, sleepers, joists, trusses, rafters, columns and heavy floors and planking, and that is Douglas fir. It is said that lumber dealers do not always distinguish between long-leaf, short-leaf, loblolly and Cuban pines; but long-leaf pine is the most important of the group. Its strength, stiffness and freedom from defects and its lasting properties fit it for many places in heavy construction. The demand for pieces of unusual size is met to a large extent by southern mills which cut this species; but "it has been roughly calculated that, at the present rate of cutting (1911), the supply of southern pines will last only from 20 to 30 years." *

The wood is also much used for interior finish, for which purpose, however, it should be finished in varnish or hard oil, as it contains too much pitch to take paint well.

(3) *Short-leaf Pine (Pinus echinata)*. The commercial range

* "Uses of Commercial Woods of the United States: II. Pines." U. S. Department of Agriculture, Forest Service. Bulletin No. 99, 1911.

of this wood lies principally in Alabama, Arkansas, Georgia, Louisiana, Missouri, North Carolina, South Carolina and Texas. It is known under many names in different localities, among them being "common yellow pine," "Virginia yellow pine" and "North Carolina yellow pine." The tree attains a height of from 60 to 90 feet and a diameter of from 1½ to 6 feet. In color, appearance and grain the wood resembles the long-leaf pine. In regard to structural qualities the wood is variable, usually hard, tough, strong, durable, resinous and lighter than long-leaf pine. It is also less elastic, and consequently, when an architect wishes timber to sustain pressure and withstand shocks he selects the long-leaf. In nearly all other situations, the short-leaf serves as well and sometimes its lighter weight makes it more desirable than the other. Its uses are as varied as those of the long-leaf.

(4) *Loblolly Pine (Pinus taeda).* This variety occurs commercially from Delaware to Florida and westward intermittently to Texas. The lumber which now reaches the market is largely of second growth and perhaps no other species in the United States at present (1913) yields so large a lumber-supply from such growth. The tree attains a height of from 70 to 120 feet and a diameter of from 2 to 4 feet. The wood resembles the long-leaf and short-leaf pines in color, general appearance and grain as it does also in general structural qualities, although it is not as stiff as long-leaf or short-leaf pine. Its flexual strength is less than that of the long-leaf but greater than that of the short-leaf pine. Its range of uses is wide and it is sold in all eastern and central parts of the United States and exported to Europe and Central America.

(5) *Cuban Pine (Pinus heterophylla).* This tree is classed among the hard pines and is found on the coast from South Carolina into Texas. It is known, also, as "slash pine," "swamp-pine" and "spruce-pine" and by other names. It somewhat resembles long-leaf pine and loblolly pine and for many years was marketed for them. It is stronger and more elastic than either. Its range of uses is as wide as those of the loblolly or long-leaf pines. Besides its use for ordinary framing it has a place among interior-finish materials and is employed for all general construction purposes. It yields readily to preservative treatment.

(6) *Western Yellow Pine (Pinus ponderosa).* Few trees have a commercial range as wide as that of western yellow pine, for it covers about one-third of the United States. It grows in the Rocky Mountain states and westward to the Pacific Ocean, reaching its best development on the coast. The tree has a number of names by which it is known in different localities, some of the names being applied to entirely different pines. It is often known as "California

white pine." Its range is so extensive that it does not present the same appearance and characteristics everywhere. It reaches a height of from 100 to 200 feet and a diameter of from 3 to 7 feet. The following are the chief characteristics of the wood: Comparatively light in weight and not strong, although heavier and stronger than the eastern white pine or the sugar pine of the far West, and in some respects, chiefly in appearance, bearing considerable resemblance to both; grain fine, often twisted; annual rings variable in width, summer-wood broad or narrow, resinous; resin-passages medium and rather numerous; medullary rays not numerous, prominent; color light to reddish, thick sap-wood almost white; not durable in untreated condition, but readily receives treatment.

Its uses range from the coarsest construction to highly finished products. House-frames, beams, joists, rafters, sills, sheathing and studding are cut in all workable dimensions. Sashes and blinds and other finished products of this wood are sold at home and abroad as white pine. It is used very largely for flooring and ceiling, is made into several kinds of interior finish, moldings, balusters, railings, newels, panels, etc., and for these purposes is shipped as far east as Wisconsin.

41. EFFECT OF TAPPING RESINOUS PINE. Tapping trees for their resin or turpentine is called "boxing" or "bleeding." It has been generally believed that the tapping of resinous pines is injurious to the strength of the timber. Recent tests, however, made by the Forest Service of the United States Department of Agriculture, have shown conclusively that this belief is erroneous. Not only are the strength, weight and shrinkage unaffected by tapping, but the chemical properties are largely unchanged; and there is no reason to believe that it in any way affects the durability of the lumber. It is difficult to discern any difference between bled and unbled timber.

42. II. SPRUCE *(Picea)*. This tree forms forests in North America and Europe and is widely distributed throughout the United States. In the statistics of forest products during recent years as many as thirty states have reported this lumber. Until very recently little attempt has been made to distinguish between various species in the statistics of spruce lumber. Maine has always been the chief spruce-lumber-producing state, still furnishing almost one-fourth of the total, and has been followed during recent years by West Virginia, Washington and New Hampshire. In 1910 the New England States produced the largest amount of spruce lumber, followed by the Pacific Coast States, the southern-Appalachian States, the Lake States and the Rocky Mountain States. The trees attain a height of from 40 to 150 feet and a diameter of from 1 foot

to 3 feet. The trees of the Sitka spruce sometimes have a diameter of 6 feet.

The wood of the spruce is soft, light in weight and resembles and is considered a good substitute for soft pine. It is light in color, generally straight-grained and compact. Spruce and fir woods have often been confused and mistaken one for the other.

It warps and twists much more than pine, and is on that account not a good wood for posts, girders and truss-timbers. It makes excellent floor-joists and studding, however, and has always been more largely used in New England for framing than any other wood. It cannot, however, be obtained in very great lengths or large sizes, except in the far West.

Next to the southern hard pines, Douglas fir and Norway pine, the author considers spruce the best framing-timber we have. It has been and is still largely used in the Eastern States for flooring and siding or clapboards and for dressed sheathing, laths, furring-stock, etc.

There are several species of spruce-furnishing timber for building purposes. The product, however, has been generally divided commercially and according to appearance, but irrespective of species, into white, black and red spruce.

1. *White Spruce (Picea alba)* predominates in the eastern United States and Canada to Labrador, and is still cut to some extent in New England.

2. *White Spruce (Picea engelmanni)* is cut in Utah, Idaho, Montana, Colorado and Wyoming.

3. *Black Spruce (Picea nigri)* is found from Pennsylvania to Minnesota, in the Allegheny Mountains to North Carolina and in Canada.

4. *Red Spruce (Picea rubens)* closely resembles the black spruce. Since 1910 it has been the principal species cut, as it is the leading species in New England and on the slopes of the southern Appalachians.

5. *Sitka Spruce (Picea sitchensis)* is the largest of all native spruces and is cut along the Pacific Coast in northern California and in Oregon and Washington. It forms, also, 20 per cent of the stand in the coast-region of south-east Alaska.

43. III. FIR *(Abies)*. This tree is found scattered throughout northern pineries from Minnesota to Virginia and northward intermittently into Canada in the Rocky Mountain regions, Coast Ranges, North-Western and Pacific Coast States. In the Western United States some of the fir trees attain a very great size, 250 feet in height and 10 feet in diameter. The wood resembles that of the spruce tree in general appearance and structural qualities, but may

be distinguished from it and from pine and larch by the fact that it has no resin-ducts. It is light in weight and, with the exception of the *Noble Fir* (*Abies nobilis*), which is hard, strong and elastic, is generally relatively soft and weak. The western varieties are used locally for various framing purposes and interior finish. The eastern varieties are occasionally used as inferior lumber.

"The term 'western fir' is used commercially to cover Alpine fir in the Rocky Mountains, white fir in the Rockies and on the Pacific Coast and the noble fir and other Pacific Coast firs." *

"The term 'white fir' is used commercially to cover two or three firs of the Rocky Mountains and Pacific Coast which are cut to a small extent for lumber. Most of the so-called 'white-fir' lumber cut is undoubtedly of the two species known as *Abies concolor* and *Abies nobilis*, the latter being known also as 'red fir' and 'noble fir.' This white fir should not be confused with Douglas fir (*Pseudotsuga taxifolia*), which botanically is not a fir and the wood of which is entirely different from that of the white fir."†

The term "balsam fir" is applied commercially to the species growing principally in the Eastern States and known botanically as *Abies balsamea*. In the lumber-production statistics it was not reported separately prior to 1907.

44. IV. DOUGLAS FIR ‡(*Pseudotsuga taxifolia*). This species, which is neither true pine, spruce, nor fir, but a sort of bastard hemlock, is now considered by many as the most important of the American woods. Its geographical range extends over ten States, from Colorado and New Mexico westward and northwestward to the Pacific Coast and to southern and central British Columbia. Its best development and heaviest stands are found in western Washington, western Oregon, northern California and Idaho and the quantity of this wood is probably greater than that of any other softwood and greater than the combined stand of all the hardwoods. Though in production it ranks second to southern yellow pine, in rapid growth, comparatively wide distribution and great variety of uses to which it can be put, it may be placed first. The completion of the Panama Canal by way of which it will be shipped to Atlantic Coast ports and other markets will undoubtedly largely increase its use.

The tree and wood are known, also, by various other names in different sections of the country, but the name "Douglas fir" has

* "The Timber Supply of the United States." Forest Service, Circular, No. 166, 1909.

† "Forest Products of the United States for 1908." Bureau of the Census, Department of Commerce and Labor. Forest Products, No. 10, 1909.

‡ In addition to the latest government reports, the Douglas Fir Sales Company of Portland, Oregon, furnished valuable data for this article.

been adopted by the Forest Service and by various trade and technical associations and is coming into general commercial use.*

The tree attains a height of from 200 to 300 feet and a diameter of from 5 to 6 feet and is vigorous, hardy and of rapid growth. The wood is hard, not very heavy and fairly durable, qualities which especially recommend it for structural purposes. It varies in color from a decided reddish tinge to a light yellow and on this account is sometimes classified as "red fir" and "yellow fir." The grain is straight, but may vary from as few as four or five to as many as forty-five rings to the radial inch. The spring-wood and summer-wood vary greatly in density, the former being soft and spongy and almost white and the latter hard, flinty and very dark.

In regard to the strength of Douglas fir, results secured from tests on structural timber of this and some other woods seem to indicate that the species examined may be grouped, according to their breaking-strength for bending, compression and shear, into three classes: Douglas fir and long-leaf pine the strongest; loblolly pine, short-leaf pine, western hemlock and western larch an intermediate group; and Norway pine and tamarack the weakest.†

In regard to the uses of Douglas fir it may be said that it is manufactured into almost every form known to the sawmill-operator and that much round or hewed timber is used which never passes through a sawmill. All sizes are supplied and pieces 30 by 30 inches in cross-section and 120 feet in length are not uncommon. Among the general industries using it are those of piling and poles; mine timbers, railroad-ties and bridge and trestle-timbers; timbers for car-construction; nearly all kinds of lumber for houses, material for furniture-makers and boat-builders; special products for cooperage, tanks, paving-blocks, boxes, etc. The large-size timbers go to all parts of the world.

For house-construction Douglas fir is manufactured in all forms

* "Douglas fir (*Pseudotsuga taxifolia*) has a number of common names by which it is known in the Pacific Northwest, 'Douglas fir,' 'red fir,' 'Douglas spruce,' or simply, 'fir.' In commerce it is also called 'Oregon pine,' 'red pine,' 'Puget Sound pine,' 'Washington fir,' and 'British Columbia pine.' Of all these names 'Douglas fir,' the one adopted by the Forest Service after a lumber-census in which this name was used more than all other names combined, is the most satisfactory, being absolutely distinctive and covering various forms of the tree which are known by local names. The terms 'red fir' and 'yellow fir' are often used to distinguish between two fairly distinct forms of wood which this single species produces, depending upon the age of the tree and the conditions under which it has grown. The term 'red fir' is applied to trees which are ordinarily immature and have rather coarse-grained and red dish-colored wood; the term 'yellow fir' applies to trees which are of mature age and whose wood is fine-grained, yellow in color, rather soft, and easily worked." See "The Growth and Management of Douglas Fir in the Pacific Northwest." Forest Service, U. S. Department of Agriculture, Circular No. 175, 1911.

† See Table 3, pages 18 and 19, "Average Results of Tests." "Properties and Uses of Douglas Fir." U. S. Department of Agriculture, Forest Service. Bulletin No. 88, 1911.

of dimension-stock. On account of its comparatively light weight combined with strength it is especially fitted for girders, joists, rafters and other timbers carrying loads. It is practically the only lumber used in some parts of the Pacific States. Its comparative hardness makes it suitable for flooring and it is used for beveled siding, sashes and doors. It has recently gained an important place for inside finish; and when the clear lumber is sawed flat-grain and shows the pleasing figures and the contrasts between the spring-wood and summer-wood, its grain is considered by many to be as attractive as that of quarter-sawed oak. The beauty of the grain is more strongly brought out by stain which the wood takes well. The chief use of Douglas-fir finish is for doors and window-casings, base-boards and all kinds of panel-work. It is also made into veneers which are used chiefly for door-panels.

45. V. HEMLOCK (*Tsuga*). There are two species of hemlock from which the woods used in building-construction and other industries are obtained, the eastern hemlock (*Tsuga canadensis*) and the western hemlock (*Tsuga heterophylla*).

1. *Eastern Hemlock (Tsuga canadensis).* This species is found all along the northern boundary of the United States and in Canada. The trees vary from medium to large size. The wood is of a light reddish-gray color, free from resin-ducts, moderately durable, commonly cross-grained, rough and splintery and holds nails firmly. It is used largely in New England for small scantlings and sheathing, or "boarding," as it is called there; it is very liable to have cup-shakes, which greatly injure it when used for framing-timbers. It is sometimes used for cheap finish.

2. *Western Hemlock (Tsuga heterophylla).* This tree forms 13 per cent of the forests of Washington and is abundant in many parts of Oregon. Its range is from Alaska southward to Marin County, California, to the coast-region in California and southern Oregon in the southern, and east to Montana in the northern portion of the belt. It reaches its best development in western Washington and Oregon, but rarely occurs in pure stands of great extent. It has been found with a diameter of 8 feet and a height of 250 feet and occasionally these dimensions have been exceeded. Mature trees are from 3 to 5 feet in diameter at breast-height and the trunk is nearly cylindrical. Western hemlock has suffered so severely through the reputation of its eastern relative that it has had comparatively little market-standing. The wood of the western species, however, is far superior to that of the eastern tree. It is suitable for use in all but the heaviest building-construction work, it is particularly valuable for inside finish, and its qualities entitle it to rank among the valuable timber-trees of this continent.

For many years farmers have used this wood for the construction of oat-bins, etc., as it is said that the wood is distasteful to all rodents.

"Experiments made in Manila indicate that western hemlock may prove of special value in tropical countries where most woods are destroyed by ants. Since the depredations of ants are of great importance, not only in the Philippines but in other tropical countries, a wood which will withstand them is certain of a good market. Although cedar and redwood have the reputation of being ant-proof, they are not adapted to many uses for which the western hemlock excels.

"There is little similarity between the wood of the eastern and western hemlock. That of the western tree is light, rather hard, straight-grained, has a sour odor, is tasteless, tough and usually white, although sometimes reddish-brown in the interior of the tree. This discoloration is a serious defect in timber used for finishing. Trees thus affected are commonly known as 'black hemlock,' and are frequently believed to belong to a different species. This does not refer to the true black or alpine hemlock, which grows only at great altitudes and is not yet available for lumber.

"In strength, ease of working and freedom from warp and shakes, western hemlock differs greatly from the eastern species, whose deficiencies in these respects are its chief drawbacks. Western hemlock can not be classed in strength with oak, Douglas fir, red fir, or long-leaf pine, nor is it suitable for heavy construction, especially where exposed to the weather; but it possesses all the strength requisite for ordinary building material. It is largely used in Washington for mill-frames.

"When green, hemlock contains much water and is very heavy; when dry it is but little heavier than spruce and in some localities no heavier.

"Hemlock is best adapted for uses which require ease of working, a handsome finish and lightness combined with considerable strength. It has been found suitable for flooring, joists and scantling, laths, siding, ceiling, box-shooks, turned stock, newel and panel-work and woodenware. It is, however, for finishing and box-manufacture that it is most certain of appreciation when it becomes better known. Taking a high polish, being free from pitch, and, when properly sawed, showing a beautiful grain, it is an excellent wood for wainscots, panels and newels. It is harder and less easily dented than redwood or cedar, and has a uniformly firm grain, which on drying, does not show the minute corrugations characteristic of Douglas fir and other trees having a marked difference between summer-wood and fall-wood." *

46. VI. LARCH OR TAMARACK (*Larix*). This wood, well known from ancient times, has two principal American species which are called, also, among other names, "hackmatack." The foliage is deciduous. The trees attain a height of from 70 to 125 feet and a diameter of from 1 foot to 4 feet. The wood is hard,

* "The Western Hemlock." United States Department of Agriculture, Forest Service, Bulletin No. 33, 1902.

heavy, strong and durable, resembling spruce in structure and hard pine in weight and appearance. The western species is generally stronger, stiffer and heavier than the eastern. It is used principally for posts, poles, sills, ship-timbers, and railroad-ties.

The term "larch" is used to designate the western larch or tamarack (*Larix occidentalis*) which is cut in Montana, Idaho, eastern Washington and Oregon.

The term "tamarack" is applied strictly to eastern tamarack (*Larix laricina*) and is cut chiefly in the Lake States, Minnesota, Michigan and Wisconsin.

47. VII. CEDAR (*Cedrus, Thuja, Chamæcyparis, Libocedrus, Juniperus*). The name "cedar" was first applied to true cedars or Lebanon cedars (*Cedrus*), of the eastern continent. Later it was applied to certain other trees belonging to different genera, all, however, more or less commonly known to lumbermen as "cedars," because of the general similarity of appearance of the growing tree, the numerous common characteristics of the wood and the similar uses to which they are adapted.

One or more species of cedars are produced in every region of the United States in sufficient quantity to be of use. The following eight species, representing four genera, are the most important, considered as a source of lumber and wood-supply:

1. *Southern White Cedar (Chamæcyparis thyoides).* The States furnishing most of the supply are Delaware, Florida, Georgia, Maryland, New Jersey, North Carolina, South Carolina and Virginia. Height of tree, from 75 to 80 feet; diameter, 2 to 4 feet (latter exceptional). Character and qualities: very light in weight, fragrant, soft, comparatively weak; grain fine, even and straight; color light brown tinged with red; easily worked; very durable in contact with the ground. Uses: rough construction, poles, posts, piles, boats, porch and piazza-columns and inside finish.

2. *Northern White Cedar (Thuja occidentalis).* The chief supply comes from the Lake States although a little is cut in about a dozen other States. Dimensions, character and characteristics: about the same as for southern white cedar. Uses: tanks, fence materials, store-fixtures. This wood is not much used by carpenters, because its softness unfits it for holding nails in members subject to stress.

3. *Red Cedar (Juniperus virginiana).* It is rather difficult to define the commercial range of this wood, but at present (1912) the chief supply comes from the region between the Ohio River and the Gulf of Mexico. The tree is found, however, from Maine to Minnesota and south-west to Texas, and south and east to those lines. Dimensions of tree: height, in parts of its range, from

80 to 90 feet; diameter (extreme), 4 feet, but in most regions not over 2 feet. Character and qualities: medium weight, soft, not strong, brittle, fragrant, grain fine, even and straight, except as interfered with by knots; color dull or sometimes bright red; easily worked; heart-wood as durable as any other American wood. Uses: posts, poles, tanks, porch-columns, out-of-doors furniture and fixtures, interior finish, indoor furniture, clothes-chests, wardrobes, etc. It is the best wood for lead-pencils.

4. *Western Juniper (Juniperus occidentalis).* The range of this tree is Idaho, eastern Oregon, through the Cascades and the Sierras to southern California. Dimensions of tree: height, 25 to 45 feet; diameter, 2 to 4 feet. Character and qualities: one of the heaviest of the cedars; soft; grain, fine and even; compact, brittle and easily split; color, brown, tinged with red; slight aromatic odor; easily worked; durable. Uses: posts, fence-material and railroad-ties. It is as yet little cut for lumber as the trunks are comparatively short for saw-logs.

5. *Incense Cedar (Libocedrus decurrens).* Although the tree's range is in certain regions of California, Oregon and Nevada, practically all the lumber that finds its way into local or general markets is cut in California. Dimensions: height of tree, from 75 to 125 feet; diameter from 3 to 6 feet. Character and qualities: very light in weight, soft, not strong, brittle; fine-grained, straight and even; compact; summer-wood dark colored, sap-wood nearly white; easily worked; very durable in contact with the soil, comparing favorably in this respect with redwood. Uses: posts, laths, shingles, inside finish and furniture.

6. *Port Orford Cedar (Chamæcyparis lawsoniana).* This tree is found in south-western Oregon and north-western California, the bulk of commercial timber being grouped chiefly in Oregon. Dimensions: height of tree, from 135 to 175 feet; diameter, from 3 to 7 feet. Character and qualities: light in weight, moderately strong; grain fine and even, compact; abounding in odoriferous resin; satiny, susceptible of a beautiful polish; color, light yellow or almost white, occasionally reddish; very easily worked and durable. Uses: lumber for general construction purposes, porch-finish, flooring, inside finish, furniture, clothes-chests, wardrobes, drawers, cabinets, etc. The odor of this cedar is offensive to most insects that attack furs, woolens, etc.

7. *Yellow Cedar (Chamæcyparis nootkatensis).* The geographic range of the yellow cedar is nearly 1,000 miles along the Pacific Coast and the adjacent islands, from Oregon to south-eastern Alaska. "It is said to be the most valuable wood in Alaska and as a cabinet-wood its beauty has been declared by some equal to that

of any other tree in North America. Its rare color and the fine polish which it takes constitute two of its chief values; but it has others, one of which is its power to resist decay in the most unfavorable situations." * Dimensions: height of tree, from 90 to 120 feet; diameter, from 3 to 6 feet. Character and qualities: rather light in weight, hard, fairly strong, brittle; grain fine, even and straight, compact; easily worked, satiny, susceptible of a beautiful polish; odor agreeable, resinous; color bright, light, clear yellow; durable in contact with soil. Uses: interior finish, flooring, cabinets, shelving, moldings, furniture. "It has been exported in considerable quantities to China, where it has been used as a substitute for satinwood." *

8. *Western Red Cedar (Thuja plicata).* This wood has been called "canoe cedar" from the fact that it was used for so many years by Indians and white men for canoes and dugouts. The tree grows in a region which embraces portions of northern California, Oregon, Washington, Idaho, British Columbia and Alaska. Washington is the center of the supply. Dimensions: height of tree, from 100 to 150 (exceptionally 200) feet; diameter, from 3 to 8 (extreme 16) feet. Character and qualities: light in weight, not strong, brittle; grain coarse, even and straight, compact; color dull brown, tinged with red, the thin sap-wood being nearly white; easily worked; durable in positions exposed to decay. Uses: shingles, western red cedar being the greatest shingle-wood in the United States; poles, large-size poles being shipped to nearly all parts of the United States under the name of "Idaho cedar"; outside finish, bevel-edge siding; frames, sashes, doors; inside finish, cabinet-work; car-siding and roofing; finish for boats, such as roofs, railings, linings and trim.

48. VIII. CYPRESS *(Cupressus, Chamæcyparis, Taxodium).* It is to these three genera that the name "cypress" has been chiefly applied. As classified in the article on cedar most species of the genus *Chamæcyparis* are now called, commercially, "cedars." The *Cupressus* is the true cypress, and while important in the East in ancient times and in Europe to-day, has little or no significance in America. The genus *Taxodium,* represented by the single species is not a cypress, but supplies the "cypress" lumber of United States commerce.

American or *Bald Cypress (Taxodium distichum).* The name "bald cypress" was given because of the leafless appearance of the trees in winter, this species being deciduous. The chief European species is an "evergreen." This tree is found in commercial quan-

* "Uses of the Commercial Woods of the United States: I. Cedars, Cypresses and Sequoias." U. S. Department of Agriculture, Forest Service, Bulletin No. 95, 1911.

tities in the South Atlantic and Gulf States and in Tennessee, Kentucky, Missouri, and a few other States. For a long time Louisiana has supplied about two-thirds of the total output of cypress lumber. It grows on submerged ground, in deep swamps and on undulating land. It has been called by many names, such as "white cypress," "black cypress," "red cypress," "swamp cypress," "deciduous cypress," "southern cypress," etc.

Dimensions: Height of tree, from 75 to 140 feet; diameter, from 3 to 6 and (in exceptional cases) 10 feet. Character and qualities: light in weight, not strong; grain rather fine, straight; summer-wood very slightly resinous; color light to dark brown, sap-wood nearly white; easily worked; very durable in contact with soil.

Uses: for almost every kind of exterior and interior finish, such as siding, shingles, piazza-columns, flooring, steps, balustrades, cornices, gutters, outside blinds, door-frames, window-frames, sashes and blinds; ceiling, wainscoting, inside shutters, mantels, grills and to some exent for interior flooring; containing little resin, it affords a good surface for paint, which it holds well; it is an excellent wood for kitchens and other rooms subject to dampness, as it shrinks, swells and warps but little; it is much used for drain-boards, sinks, kitchen and pantry-tables and cupboards; all kinds of cooperage; farm-lumber, such as silos, troughs, flumes, stable-floors and fences; telegraph and telephone-poles; greenhouse and hothouse-construction as it resists dampness and excessive heat; numerous miscellaneous uses.

A peculiar fungus-disease attacks the living trees causing cavities in the wood resembling perforations made by pegs, and giving the names "peggy," "pecky" and "blotty" to the cypress lumber. This lumber is not as strong as the unaffected wood but seems to be just as durable.

49. IX. REDWOOD *(Sequoia)*. The redwood-belt extends in a strip, 500 miles long and from 10 to 30 miles wide, from southern Oregon to central California. The commercial range covers about 3,000 square miles, the dense logging-woods, however, covering a much smaller area. The heaviest stand is near the center of the redwood region, in Humboldt County, Cal. Redwood lumber is produced only in California and is the only important kind of lumber limited to one state. But two species of sequoias grow in the United States.

1. *Common Redwood (Sequoia sempervirens)*. This tree grows in the belt mentioned above. Mature trees attain an age of from 500 to 800 years, 1373 years being estimated as the greatest age. Dimensions: height, from 180 to 280 (occasionally over 300) feet; diameter, from 6 to 10 (sometimes 15) feet. Character and quali-

ties: light in weight, soft, moderately strong, brittle; grain fine, even, straight, sometimes curly; color, light to dark red with sap-wood nearly white; splits and works easily and polishes well; very durable in contact with the soil; kindles and burns more slowly than almost any other wood.

Uses: redwood lumber enters into practically every part of the house and it is used largely for siding, shingles, porch-columns, cornices, sills, rafters, joists and studding. It is considered by many too soft to be used for flooring. For interior finish it meets almost every requirement, such as ceilings, wainscoting, paneling, moldings, stair-work, mantels, etc. It is often finished to show the beautiful grain, texture and color. Redwood doors are light and strong, holding their shape well, without swelling or shrinking. It has been largely used, also, for railroad-ties, cars, tanks, flumes, furniture, etc. There are exquisite redwood veneers and burls.

2. *Giant Redwood or "Big Tree" (Sequoia washingtoniana).* The stand of the "big tree" is restricted to a few isolated groves on the western face of the Sierra Nevadas in California lying at altitudes of from 5,000 to 8,000 feet. It is the largest tree in America, mature trees attaining a height of from 200 to 350 feet and diameters of more than 25 feet. Character and qualities: very light, soft, weak, brittle; grain coarse, even and straight; color bright, clear red, turning much darker with exposure; very easily split and worked; remarkably durable in contact with the soil.

Uses: the big tree is of sentimental rather than of commercial importance. Some of the finest specimens are the property of the United States Government and are carefully protected. Trees have been found which have stood for 3,000 and even 4,000 years and the bark sometimes attains a thickness of two feet. The wood has been used for inside finish, framing, siding and shingles; but as it is weak it is not suitable for heavy work even though the great size of the tree might seem to recommend it.

50. B. THE BROAD-LEAVED WOODS. The broad-leaved trees are found in nearly every country of the globe and they furnished the woods used in construction and for other purposes until the advent of the American softwoods. As a rule the trees do not afford large pieces and the total output is less than that of the needle-leaved woods. Most of the trees are deciduous, that is, shedding their leaves every season, although some are "persistent" or "evergreen." The terms "broad-leaved," "deciduous" and "hardwood" are used interchangeably. These woods are used for house-finishing, cooperage, vehicle-manufacture, agricultural implements, musical instruments, car-building, railroad-ties, poles and posts.

The hardwood-supply of the United States is rapidly waning, ad-

vancing prices are reflecting the dwindling output and there is a relaxation of the rules by which hardwood lumber is graded and sold.

51. I. ASH (*Fraxinus*). This is one of the most widely distributed of all woods and is commercially reported from thirty-nine States. The woods of ash and oak trees are similar in general appearance but ash is coarser, less attractive, easier to work, tough, elastic and somewhat lighter in weight than oak. When exposed to the weather ash is not durable; but it seasons well. The woods are commercially separated into white ash and brown (or black) ash. The following six species are the commercially important ones growing in the United States:

1. *White Ash (Fraxinus americana)*. Found growing from Nova Scotia to Florida and westward to Minnesota and Texas. Height of tree, 45 to 90 feet and diameter, from 3 to 4 feet. Color, light. Grain, coarse. Structure, compact. Heavy, hard, strong, elastic, brittle with age and only fairly durable in contact with the soil. Used for interior and cheap cabinet-work, furniture, agricultural implements, cars, carriages, tools, oars, etc. Worked more easily than oak and when thoroughly kiln-dried can be used for solid doors. The finished wood resembles bastard-sawed oak, except that the grain is much coarser and the wood more porous. It shrinks moderately, seasons with little injury, stands well and takes a good polish.

2. *Black Ash (Fraxinus nigra)*. This is commercially known, also, as "brown ash." Northern and northern-eastern States to Virginia and westward to Manitoba and Arkansas. Height of tree, from 70 to 80 feet and diameter from 1 foot to 1½ feet. Color, brown. Grain, coarse. Structure, compact. Wood rather soft and heavy, tough, elastic, not strong nor durable when exposed. Used for interior finish, cabinet-work and fencing. The excrescences on these trees, known as "burls," have a distorted grain which makes them valuable for veneers.

3. *Red Ash (Fraxinus pennsylvanica)*. Found from New Brunswick to Florida and westward to Dakota and Alabama. The term "pennsylvanica" refers to the locality in which it is well developed. Height of tree, not over 45 feet, and diameter not over 1½ feet. Color, brown; structure, coarse-grained and compact; heavy, hard, strong and brittle. Used in agricultural implements, handles, boats, oars, etc. Often confused with and substituted for the more valuable white ash.

4. *Blue Ash (Fraxinus quadrangulata)*. Found in the central States, Mississippi Valley, Michigan and southward. Height of tree, from 50 to 75 feet; diameter from 1 foot to 2 feet. The inner bark colors water blue. Color, light yellow or brown; grain, close;

structure, compact and satiny; hard, heavy, brittle, not strong. The most durable of the ash woods. Used for flooring, carriage-building, tool-handles, etc.

5. *Green Ash (Fraxinus lanceolata).* Found east of the Rocky Mountains, in Vermont and northern Florida and intermittently to Utah and Arizona. Height of tree, from 40 to 50 feet and diameter from 1 foot to 2 feet. Color, brownish; grain, coarse; structure, compact; hard, heavy, strong, brittle. The southern green-ash wood is usually classed as white ash and its representative uses are similar to those of the latter.

6. *Oregon Ash (Fraxinus oregona).* Found on the Pacific Coast, from Washington to California. Height of tree, from 50 to 75 feet and diameter, from 1 foot to 1½ feet. Color, light brown; grain, coarse; structure, compact; rather light in weight, hard, not strong. Used for furniture, carriage-frames, and cooperage.

52. II. BASSWOOD (*Tilia*). This name is applied also to the trees known as "limes," "lime-trees," "linds," "lindens," "tiels," "tiel-trees" and "bass-trees." The wood is esteemed for its working-qualities, which, although inferior to those of whitewood, still resemble them. The name "basswood" is commercially interchangeable with "whitewood" or "tulip-tree wood," "poplar" or "cottonwood" and "cucumber-tree wood," as they are all noted for the soft, fine qualities which make them suitable for carvings, wooden-ware, etc. They are unrelated, however, botanically. The trees grow from New Brunswick to Georgia and westward to Nebraska and Texas. Their height varies from 60 to 90 feet and their diameter from 2 to 4 feet. Color, light or reddish brown; structure, very straight, close-grained and compact; light in weight, soft, easily worked, tough, not strong nor durable. Used for carvings, drawer-sides and backs, bodies of carriages, etc.

53. III. BEECH (*Fagus*). The only American representative of this tree is the common beech (*Fagus atropunicea*). It grows from Nova Scotia to Florida and westward intermittently to Wisconsin and Texas. Height of tree, from 60 to 80 feet and diameter from 2 to 4 feet. Color, white to light brown or reddish; hard, heavy, strong; not durable when exposed, tough; subject to attack by insects; liable to check during seasoning. It takes a fine polish and is used for furniture, flooring, inside finish (to a limited extent), shoe-lasts, plane-stocks, ship-building, wagon-making.

The name "ironwood" has been given to the Blue Beech (*Carpinus caroliniana*), a small tree growing from Quebec to Florida and westward to Nebraska and Texas; to the Hornbeam (*Ostrya virginiana*), a small tree also, growing from Nova Scotia to Florida

and westward to Dakota and Texas; and to several other North American species producing unusually heavy and hard woods, used for tool-handles and various implements. These woods, however, are not used in building-construction on account of their great weight.

54. IV. BIRCH (*Betula*). This is one of the northern hardwoods which has come to figure extensively in lumbering-operations within the last few years in regions where the white-pine supply has been exhausted. It is beginning to rank as one of the more valuable woods. Wisconsin maintains a steady lead in the output. The commercial names do not follow the botanical classifications. Several species are cut, but the greater portion of the output is furnished by what are known in the market as the "black birch," "sweet birch," "yellow birch," and "white" birches. Western birch, cut in Washington, was reported for the first time in 1910.

The birches are medium-sized trees, form extensive forests northward and occur scattered in all broad-leaved forests of the eastern United States.

The wood is heavy, hard, strong and of fine texture; the sap-wood is whitish in color; the heart-wood appears in shades of brown, red and yellow. It is very handsome when finished, takes a good polish, has a satiny lustre, shrinks considerably in drying but works and stands well. It is used for inside finish and is one of our handsomest hardwoods. The figured North Carolina birch ranks among our most expensive native woods. The banquet-hall of the Auditorium Hotel in Chicago was finished in birch. The wood is often used to imitate cherry and mahogany, the grain of all these woods being much the same.

The following are the principal species of birch occurring in the United States:

1. *White Birch (Betula populifolia)*, growing along the Atlantic Coast from Canada to Delaware. This is a soft, weak wood.

2. *Paper Birch (Betula papyrifera)*. This is called, also, locally, "white birch," "canoe birch" and, in Quebec, "boleau." It grows in the northern United States and in Canada and Alaska. The wood is hard and strong.

3. *Red Birch (Betula nigra)*. This is called, also, locally, "black birch," "river birch," "water birch" and "blue birch." It grows from Massachusetts to Florida and westward intermittently to Minnesota and Texas. The wood is rather hard and strong.

4. *Yellow Birch (Betula lutea)*. This is called, also, locally, "gray birch," "swamp birch," "silver birch," and in Quebec, "mérisier" and "mérisier rouge." It grows from Newfoundland to North Carolina, and westward to Minnesota and Texas. The wood

is heavy, very strong, hard, tough, susceptible of a high polish and suggests the qualities characteristic of maple.

5. *Sweet Birch (Betula lenta).* This is called, also, locally, "black birch," "mahogany birch," "cherry birch," "river birch" and "mountain mahogany." It grows from Newfoundland intermittently to Illinois and southward along the Alleghanies to Kentucky, Tennessee and Florida. The wood is heavy, very strong, hard, close-grained and compact; is easily stained; and takes a high satin-like polish. The wood is often stained to resemble cherry and mahogany.

6. *Western Birch (Betula occidentalis).* This is called, also, locally, "Washington birch." It grows in British Columbia and in northwestern Washington, reaching its highest development along the lower banks of the Fraser river in British Columbia. It is one of the largest of the birch trees, and, with the exception of the cottonwood, is the largest of the deciduous trees of north-western North America. Its characteristics are similar to those of the paper birch.

55. V. CHERRY (*Prunus*). The lumber-furnishing cherry tree of this country, the wild black cherry (*Prunus scrotina*), is a small to medium-sized tree, scattered through many of the broad-leaved woods of the western slopes of the Alleghanies, but is found, also, from Michigan to Florida and west to Texas.

Cherry has become a rare wood and during the past few years it has been, next to walnut, the highest-priced lumber produced in the United States. West Virginia and Pennsylvania have led in its production.

The wood is fairly light in weight, hard, strong and of fine texture; the sap-wood is yellowish-white and the heart-wood, reddish to brown. It shrinks considerably, but works and stands well, takes a good polish and is much esteemed for its beauty. It is used principally for fine interior finish, cabinet-work and furniture, and is often stained to imitate mahogany. It cannot be obtained in wide boards, and, the grain being fine, it is most suitable for work that is much cut up or molded.

56. VI. CHESTNUT (*Castanea*). Three of the four known species of the genus *Castanea* grow in North America: 1, the *Common Chestnut (Castanea vulgaris* or *dentata); 2,* the *Chinquapin (Castanea pumila);* and, 3, a plant. The 4, *Chinquapin (Castanopis chrysophylla)* is a tree with characteristics between those of the oak and the chestnut and is the only North American representative of a genus including twenty-five species. (For Horse Chestnut, see Art. 65.)

The chestnut is among the largest of our hardwood trees, and

in the region of its best development has been known to reach a height of 120 feet and a diameter of great size. Throughout the greatest part of its range, however, it is much smaller, with an average height of from 80 to 100 feet and a diameter of from 2 to 4 feet. It is distributed throughout the eastern part of the United States and ranges from southern Maine southward through New England. It is common in Rhode Island and Connecticut and as far south as Delaware and is found, also, in the Province of Ontario and in the Eastern States, especially New Jersey, Pennsylvania, and parts of Maryland. Further south it is found along the Appalachians to Alabama. In the Middle West it is confined to Michigan, Indiana and Illinois.

"Chestnut timber is in great demand. The wood is light, moderately strong, coarse-grained, and elastic. It works easily and is very durable in contact with the soil. In seasoning, the wood often checks and warps, but damage from this source is not serious. It is used in cabinet-work and cooperage, and for fence-posts, telegraph and telephone-poles, ties, and mine-timbers. The presence of tannin in the wood increases the demand for small-sized and inferior material and large quantities are used in the manufacture of tanning-extracts.

"Except in portions of the Southern Appalachians, very little of the original chestnut remains; but the coppice*-reproduction is so rapid that a considerable supply of small-sized timber is still available. The excellent qualities of the wood insure a permanent demand and good price." †

It is adapted for situations in which lightness and durability rather than much transverse strength are required.

The future supply, however, is threatened by a fatal bark-disease which has already resulted in great damage in New York, New Jersey, Connecticut and eastern Pennsylvania.

57. VII. ELM (*Ulmus*). Though there are seven or more species of elm growing in the United States, only three are commercially important as lumber. These are 1, the *White, Soft* or *American Elm (Ulmus americana),* growing from Newfoundland to South Dakota and south through western Nebraska to Texas; 2, the *Cork* or *Rock Elm (Ulmus racemosa),* growing from Quebec to Vermont and westward intermittently to Nebraska and Tennessee; and 3, the *Slippery* or *Red Elm (Ulmus pubescens),* growing from the valley of the lower St. Lawrence southward to Florida, Alabama and Texas and westward through southern Canada and the United States as far as North Dakota and central Kansas. Wisconsin has

* Bush-thicket.

† U. S. Department of Agriculture, Forest Service Circular No. 71, January 19, 1907.

led in the manufacture of elm lumber for a number of years, Michigan coming next.

The size of the elm varies from medium to large and is found scattered, sometimes quite abundantly, in all the broad-leaved forests of this country. The wood is heavy, hard, strong and very tough; moderately durable in contact with the soil; commonly cross-grained and difficult to split and shape; liable to warp and check considerably in drying, but standing well if properly handled; and capable of taking a high polish. The heart-wood is brown with intermixed shades of gray and red and the texture ranges from coarse to fine. Elm has been used only to a slight extent in buildings, but its use for interior finish is gaining. Much of the wood has a beautifully figured grain and is used in the manufacture of all kinds of furniture. It is used, also, for cars, wagons, boats, ship-building, bridge-timbers, barrel-staves, sills and ties. It appears to be suitable for staining where colored effects are desired.

58. VIII. GUM (*Liquidambar and Nyssa*). The North American trees commonly known as "gums" belong chiefly to the species *Liquidambar styraciflua,* a member of the "witch-hazel" famliy, which includes the commercially known "red gum" or "sweet gum"; and to the genus *Nyssa,* a wholly unrelated family to which the well-known "dogwoods" (*Cornus*) are closely connected botanically, and to which, also, the commercially known "black gum" or "sour gum," "tupelo" or "bay poplar," "pepperage," "white gum," "cotton gum," etc., belong.

1. *Red Gum (Liquidambar styraciflua).* This is known, also, as "sweet gum," and is one of the woods which has become prominent in recent years. It is widely distributed throughout the central and southern States, but Arkansas has been the largest producer. Mississippi, Missouri and Tennessee follow. The earlier name "sweet gum" originated from the domestic use, for chewing, made of the sweetish gum obtained from the tree. The latter name "red gum," was given on account of the reddish-brown color of the wood. The names "satin-walnut" and "star-leaved gum" are sometimes given, commercially, to this wood.

It is heavy, rather soft, strong, stiff, not durable when exposed and liable to shrink and warp badly in seasoning. It will take a high polish. It is used principally for veneers, cabinet-work, shingles, clapboards, etc. It has been used locally for framing and in some districts of Kentucky it has been the common framing-lumber. Selected pieces so resemble black walnut that they are cut into veneers for use in the manufacture of furniture.

2. *Black Gum* or *Sour Gum (Nyssa sylvatica).* The term "tupelo" is used, commercially, chiefly to designate the wood of this

tree, of the cotton gum (*Nyssa aquatica*) and of the water gum (*Nyssa biflora*) and it is often called, locally, "bay poplar" or "pepperage." It is associated with cypress and is cut principally by the manufacturers of cypress lumber. The tree is found commercially from Connecticut southward and westward to Texas and southern Michigan. Louisiana leads in its production.

The three other species of the genus *Nyssa* are:

3. *Water Gum (Nyssa biflora)*, growing from Maryland to Florida and central Alabama. "The bulk of the lumber coming to the market as Tupelo is of this species." *

4. *Sour Tupelo (Nyssa ogeche)*, growing in South Carolina, Georgia and Florida.

5. *Cotton Gum (Nyssa aquatica)*, known locally, also, as "large tupelo," "tupelo gum," "sour gum," "swamp tupelo," "tupelo," "swamp gum," "olivetree," etc., and growing in the coast-region from southern Virginia to northern Florida, through the Gulf States to Texas, northward through Arkansas, and westward and southward along the Ohio and Mississippi River valleys in Tennessee and Kentucky and in southern Missouri and Illinois.

"All the species of the *Nyssa* genus of gums, except the sour tupelo, yield woods that are now being used extensively for commercial purposes. The wood has remarkably twisted fibers, which render it very difficult to split, and some gums are much used for heavy wheel-hubs, rollers, and farm-implements. Gum woods are used, also, for a great many other purposes, such as flooring, siding, piano-tops, turned columns, packing-cases, crates, boxes, baskets, pump-logs and cross-ties. The wood of the water gum and cotton gum is suitable, and now used to a considerable extent, for grills, coffins, sounding-boards of musical instruments, slack-cooperage stock, turned table-legs, spindles, balusters, and various other constructional purposes. It is used, also, for paper-pulp, the fibers of the wood being as long as those of basswood and the color good enough for print-paper. The demand for these woods will doubtless continue to increase and later they will probably replace, to a certain extent, a great many other woods now used for the above purposes." *

59. IX. MAPLE (*Acer*). The maples are found on all continents of the northern hemisphere. The principal European species (*Acer pseudo-platanus*) is known as the "European sycamore" and the sugar maple or hard maple (*Acer saccharum*) is one of the principal deciduous trees of North America. The trees are medium-

* "Distinguishing Characteristics of North American Gumwoods." U. S. Department of Agriculture, Forest Service Bulletin No. 103, Oct. 28, 1911.

sized, sometimes forming forests and frequently constituting a large proportion of the arborescent growth. In the United States the maples used for lumber include the sugar or hard maple, the silver or soft maple, the red or swamp maple and the Oregon or broad-leaved maple, the first mentioned of the four constituting much the larger part of the total. Michigan has for many years ranked first in maple-lumber production.

1. *Sugar Maple* or *Hard Maple (Acer saccharum).* This is called, also, "rock maple." It is a large tree, with an average height of 80 and a diameter of 3 feet and ranging from Newfoundland to Florida and west to Minnesota, Nebraska, Kansas and Texas.

"The wood of the sugar maple is heavy, strong, dense and very hard, but not durable in contact with the soil. It will take a fine polish and is used in large quantities for interior finish, floors, musical instruments, furniture, wooden-ware, vehicles, cooperage and novelties. The wood stands well alternate wetting and drying and is therefore one of the best for the manufacture of washing-machines. 'Curly maple' and 'bird's-eye maple,' obtained from this species, are desirable for finishing and cabinet-work. The wood makes charcoal of unsurpassed quality, is a source of wood-alcohol and has a very high fuel-value." *

2. *Silver Maple* or *Soft Maple (Acer saccharinum).* The silver maple grows to a large size, frequently attaining, in rich alluvial soils, a height of 115 and a diameter of from 3 to 5 feet. The tree is found from New Brunswick to western Florida. The western limit of its range is in the eastern portion of the Dakotas, Nebraska, Kansas and Oklahoma.

The wood is light and neither strong nor durable; brittle and easily worked; and will take a high polish. It is used to a considerable extent for seats and cushion-frames in cheap buggy-work; for woodenware and turned work; and sometimes for flooring and furniture. The quality of the wood, however, is inferior.

3. *Red Maple* or *Swamp Maple (Acer rubrum).* This is called, also, "water maple" and several other names, locally. The height of the tree varies from 60 to 80 feet and the diameter from 2½ to 4 feet. Its range is about the same as that of the silver maple.

The wood is easily worked, heavy, hard, not strong, and possesses structural qualities between those of the sugar maple and silver maple. It is used largely in cabinet-work, turnery and wooden-ware.

4. *Oregon Maple (Acer macrophyllum).* This is known, also, as "broad-leaved maple." The tree reaches a height of from 70 to

* "Sugar Maple." U. S. Department of Agriculture, Forest Service, Circular No. 95, April, 1907.

100 feet and a diameter of from 3 to 5 feet and ranges along the Pacific Coast from Alaska to Oregon.

The wood is light, hard and strong, will take a polish and is used locally for furniture, turned work and tool-handles.

5. *Boxelder* or *Ash-leaved Maple (Acer negundo)*. This is a true maple, very widely distributed from Canada to Mexico and from the Atlantic Ocean to the Rocky Mountains. The trees reach a height of from 40 to 70 feet and a diameter of from 1½ to 3 feet.

The wood is soft, light and not strong and is not particularly noted, although used for woodenware, cooperage and, occasionally, interior finish.

60. X. OAK *(Quercus)*. Of the approximately three-hundred species of oaks known in the world, about fifty-three, exclusive of varieties and hybrids, are found in the United States. Not more than thirty-five of these fifty-three species are in any way commercially useful, and again, there are only about twenty-five of these which are valuable as lumber or likely to become so. The thirteen most important of these twenty-five oaks are known commercially as (1) White Oak, (2) Red Oak, (3) Chestnut Oak, (4) Chinquapin Oak, (5) Bur Oak, (6) Spanish Oak, (7) Texas Red Oak, (8) Post Oak, (9) Cow Oak, (10) Overcup Oak, (11) Swamp White Oak, (12) Water Oak and (13) Tanbark Oak. Of these, again, the first six are the most used.

The trees of the different species vary greatly in the form and character of their leaves, fruit, bark and general appearance; but there are no such marked constant characteristics as these present in the wood structure itself, by means of which these different species can be readily distinguished.

The enormous demand for standard kinds and species of woods in recent years, has caused the substitution of similar or entirely different woods for many well-known and long-used ones. Some substitutes are as good as the originals, others are inferior; and departures from the terms of specifications have led to controversies and expensive lawsuits. For some purposes, for example, the woods of the cow oak, overcup oak, post oak, bur oak or swamp oak are as good as those of the white oak; but the substitution of the somewhat similar black oak or red oak for true white oak is less easily defended, because these substitutes are very different in quality from any of the white-oak woods.

The oaks are found on all of the continents of the northern hemisphere and at some high altitudes just south of the equator. No other wood has so many different uses and for this reason it is in greater demand than any other hardwood. Its production is more evenly distributed than that of any other species with the possible

exception of ash. An idea of the wide distribution of the commercial types of oak may be gained from the fact that thirty-seven states reported the manufacture of oak lumber in 1910. The reported production consists chiefly of white oak and red oak or species accepted by the trade under these names. The center of production shifted from southern Indiana in 1899, to eastern Kentucky in 1910.

The oaks vary from medium to large-sized trees, forming the predominant part of a large portion of our broad-leaved forests.

They may be divided commercially into three general groups, (1) White Oaks, (2) Red Oaks and (3) Live Oaks. This division is a botanical one, also, based not only upon differences in anatomical structure in the wood itself, but also upon the time required by fruit to reach maturity and upon the "persistence of foliage," that is, its evergreen or deciduous character. The (1) White Oaks include such species as white oak, chestnut oak, bur oak, post oak, cow oak, etc.; the (2) Red Oaks include the red oak, Spanish oak, pin oak, black oak or yellow oak; and the (3) Live Oaks include the Southern live oak, California live oak, cañon live oak.

Of the white oaks and red oaks the former is the stronger, tougher, less porous and more durable. The red oaks are usually of coarser texture, more porous, often brittle, less durable and even more troublesome in seasoning than the white oaks. The live oaks, now become scarce but once largely employed in ship-building, possess all the good qualities and characteristics, except size, of the white oaks, and in some even surpass the latter. In structure they resemble the red oaks, but are much less porous and have always been regarded as among the heaviest, hardest and most durable building timbers of the United States.

1. *White Oak (Quercus alba).* This tree, of great economic importance and the most widely employed of all American oaks, is common in the eastern United States and attains its best development on the western slopes of the Alleghany Mountains and in the central-Mississippi and lower-Ohio basins. It varies in height from 60 to 100 feet and in maximum diameter from 2 to 4 feet. The wood is tough, close-grained, strong, hard and heavy. It is durable in contact with the soil, but if not properly seasoned is liable to check in the open air. A cubic foot of seasoned wood averages 46 pounds in weight. Sawed lumber, ties and cooperage are three of the chief uses for this wood, the first-mentioned forming the largest market.

In recent years one of the most important features in the manufacture of white-oak lumber has been the marked increase in quarter-sawing. This is a method of milling in which the boards are

cut nearly parallel with the pith-rays, exposing a beautiful silver grain. (See Art. 19.)

"Quarter-sawed lumber from the Appalachian region is shipped mainly to northern and southeastern furniture-cabinet factories, where much of it is used as a substitute for black walnut, cherry and mahogany. Some of it is manufactured into panels, ceiling, moldings and other high-grade interior finish. Plain-sawed oak is shipped to planing and finishing-mills for manufacture into flooring, ceiling, and other interior woodwork. A great deal is used also in the manufacture of the cheaper grades of furniture and for carriages, wagons, farm-tools and agricultural machinery. Considerable white-oak lumber of the best grades is used locally in Tennessee for tongues, reaches, bolsters, wheel-felloes and framing. It is the best all-around wood for this purpose, equaling ash, red oak and chestnut oak in strength and toughness, and excelling them all in durability. The poorer grades of white-oak lumber are used locally for flooring and ceiling, or for fencing, storm-sheeting, outside finish, heavy packing-cases for pianos and the like.

"Large quantities of high-grade white-oak dimension-stuff and boards, both plain and quarter-sawed, are used each year in the manufacture of railroad-coaches. There is, in addition, a special grade known as 'car-stock,' cut from inferior timber and consisting of boards, planking, beams and dimension-stuff of all sizes, which is used extensively in the manufacture of freight-cars and box cars. Car-stock is usually cut from small, scrubby timber, or from larger trees which are 'limby,' 'knotty,' or defective from pinworms. Sound knots, stains, 'cat-faces,' and wormholes, all of which seriously lower the grade of ordinary lumber, do not count as defects in car-timbers.

"Bridge-timbers and switch-ties are cut from the same kind of material and under the same specifications with regard to defects."

"Of the secondary uses of white oak, the most important are for veneer, wagon-spokes, tool-handles, chair-stock and table-stock. For furniture-veneer only the best, clear, white oak is used, the specifications usually requiring logs 28 inches or over in diameter at the small end. These logs are cut into quartered-oak veneer, from 1/4 to 1/20 of an inch thick, for use over cores of inferior wood. Smaller and rougher white-oak timber is used for basket-veneer. The strongest and highest-priced market-baskets and bushel-baskets are made entirely from white oak." *

Owing to the diminishing supply of white-oak timber, cheaper woods of other species have been substituted for it, notably red oak and chestnut for interior finish and furniture and yellow pine for flooring, interior finish and ceiling.

2. *Red Oak (Quercus rubra).* Red oak is one of the largest trees of the forests of the Northern States. Mature trees average from 70 to 90 feet in height and attain a diameter of from 2 to 4 feet.

* "White Oak in the Southern Appalachians." U. S. Department of Agriculture, Forest Service, Circular No. 105, July 25, 1907.

Its natural range is from Nova Scotia to points west of Lake Superior and south to Kansas and northern Georgia. It is found associated with other varieties of oaks, and, like white oak, with other hardwoods. Like the other oaks, red oak is not seriously affected by insects or disease.

"The wood of red oak is heavy, hard, coarse-grained, strong and moderately durable. The silver grain and large pith-rays are very conspicuous when the logs are quarter-sawed. It is inferior to white oak when great strength is required, and in the ground does not last as long as the latter; but it is more easily worked and is often preferred for interior finish and cabinet-work. Good red oak is often sold as white oak, and for most purposes the two need not be distinguished. Ordinarily it is distinctly better than other species of the red-oak group." *

3. *Chestnut Oak (Quercus prinus).* Maine to Georgia and westward intermittently to Kentucky and Alabama. Heart-wood, yellowish or reddish brown and sharply defined from the lighter and slightly reddish, narrow sap-wood. Wood, hard, heavy, strong, tough, moderately close-grained and durable in contact with the soil. Sometimes mistaken for white oak *(Quercus alba)* but distinguished from the latter by its more prominent pith-rays and the lack of a faint, reddish tinge present in the wood of white oak. Used largely for railroad-ties.

4. *Chinquapin Oak (Quercus acuminata).* Eastern New York, westward to Kansas and southward to Mississippi and into Texas. Heart-wood, light brown or slightly tinged with red; sap-wood thin and lighter-colored. Wood, hard, heavy, strong and close-grained. Durability and rate of growth similar to that of chestnut oak (*Quercus prinus*). Used largely for fencing, railroad-ties, cooperage and wheels.

5. *Bur Oak (Quercus macrocarpa).* Maine to Manitoba, southwest to Texas and westward intermittently to Montana. Its lumber never distinguished on the market from white oak. The most valuable timber of the American oaks. Attains its largest size and greatest value in southern Indiana. Heart-wood, dark, rich brown in color; sap-wood thin and much lighter in color. Wood, hard, heavy, very strong and tough, close-grained and not liable to warp or check. Uses similar to those of white oak.

6. *Spanish Oak (Quercus digitata).* New Jersey and Florida and westward intermittently to Illinois and Texas. The wood occasionally confused with that of the red oak *(Quercus rubra).* Heart-wood reddish; sap-wood thick and lighter colored, with a

* Forest-Planting Leaflet. "Red Oak." U. S. Department of Agriculture, Forest Service, Circular No. 58, January 19, 1907.

slightly brownish tinge; heart-wood similar to that of red oak, except that it is tinged a brighter red; light in weight; moderately hard and strong; and not durable in contact with the soil. Little used in construction but largely used for fuel. Bark rich in tannin.

7. *Texas Red Oak* or *Texan Oak (Quercus texana).* Valley of the Mississippi River and into Texas. Wood of this oak is the chief substitute for red oak *(Quercus rubra)* and distinguished with difficulty from the latter species. The light yellowish tinge of Texas oak and its narrow annual rings of growth serve usually to separate it from red oak. Heart-wood reddish brown, closely resembling that of red oak; sap-wood light and sometimes tinged with yellow. Wood, hard, heavy, close-grained, moderately tough and not durable in contact with the soil. Sometimes taller than any other American oak. Uses similar to those of red oak.

8. *Post Oak (Quercus minor).* East of the Rocky Mountains, Massachusetts to northern Florida and westward intermittently to Nebraska. The most widely distributed oak in the Gulf States west of the Mississippi River. Resembles white oak and seldom distinguished from it commercially; but may be distinguished from it structurally by its more numerous and conspicuous pith-rays and smaller pores in the early wood. Heart-wood light brown or sometimes tinged with red. Sap-wood thick and lighter-colored. Wood very heavy, hard, close-grained and in durability compares favorably with white oak. Used largely, particularly in the southwest, for construction, fencing, ties, cooperage, etc.

9. *Cow Oak (Quercus michauxii).* South-eastern United States, Delaware and Florida and westward along the Gulf to Texas. Also southern Indiana and Illinois to the Gulf. Wood, more nearly like white oak than that of any other species, but lighter-colored. Heart-wood light brown or slightly tinged with red; sap-wood thin and somewhat lighter-colored. Wood, heavy, hard, tough, close-grained and durable in contact with the soil. In the form of lumber, seldom distinguished from white oak. Used for building-construction, agricultural implements, wheel-stock, etc.

10. *Overcup Oak (Quercus lyrata).* In wet lands from Maryland to Texas and in the Mississippi River valley to Illinois. In general appearance, physical characteristics and rate of growth, similar to white oak and sometimes confused with it; but readily distinguished from latter by its larger and more numerous pores in the early wood. Heart-wood, dark brown and easily distinguished from the thick, lighter-colored sap-wood. Wood, moderately hard, rather heavy, strong and very durable in contact with the soil. Uses are similar to those of white oak.

11. *Swamp White Oak (Quercus platanoides).* Southern Maine westward to Michigan and Missouri and southward to Georgia. Superficially resembles white oak, from which it is distinguished by its very light-brown color, contrasting more or less sharply with the reddish-brown color of white-oak wood. Heart-wood light brown, sometimes slightly tinged with red; sap-wood rather thin and somewhat lighter-colored. Wood, very hard, heavy, strong and as durable in contact with the soil as white oak

proper. Used for building-construction, interior finish, cabinet-work, carriage and boat-building, fencing, railroad-ties, etc.

12. *Water Oak (Quercus nigra).* South from Delaware to Florida and into Texas and into the Appalachian Mountains. Heart-wood light brown, tinged with yellow; sap-wood rather thick and lighter-colored. Wood, hard, rather close-grained and not durable in contact with the soil. Little used in construction.

13. *Tanbark Oak (Quercus densiflora).* Southern Oregon and California, west of the Sierra Nevada mountains. Heart-wood light brown or tinged with red; sap-wood thick, dark brown or often tinged with yellow. Wood, very hard, heavy, strong and close-grained. Old and slow-growing trees produce wood that is very brittle and not durable in contact with the soil. Little used in construction.

Among the American live oaks may be mentioned the four following:

14. *Southern Live Oak (Quercus virginiana).* Southern States, from the coast of Virginia to Florida and westward to Texas and Lower California, southern Mexico, Central America and Cuba. Trees reach a height of from 50 to 60 feet and a diameter of from 3 to 6 feet. Foliage, evergreen, the trees resembling apple-trees in general appearance. Heart-wood light brown, tinged with yellow; sap-wood very thin and cream-colored or sometimes nearly white. Wood, very hard, heavy, strong, tough, difficult to work, easy to split, capable of receiving a high polish and very durable in contact with the soil. Principal use has been for ship-building.

15. *California Live Oak (Quercus agrifolia).* California. Heighth of tree from 40 to 75 feet; diameter from 3 to 6 feet. Foliage, evergreen; shape of tree similar to that of the apple-tree. Heart-wood light brown tinged with red; sap-wood thick and slightly darker-colored. Wood, hard, heavy, close-grained and rather brittle. Little used in construction.

16. *Cañon Live Oak (Quercus chrysolepis).* West of the Rocky Mountains, in cañons and high elevations. Manner and rate of growth similar to same in Eastern live oak. Height of trees, from 50 to 80 feet; diameter, from 3 to 6 feet. Foliage evergreen. Heart-wood, light brown, sometimes tinged with red; sap-wood generally quite thick and sometimes darker-colored than heart-wood. Wood, very hard, heavy, strong, tough, difficult to work and not durable in contact with the soil. Used principally in making wagons, implements, tool-handles, etc.

17. *Highland Live Oak (Quercus wislizeni).* In California southward from Mt. Shasta into Lower California. Height of tree from 70 to 80 feet; diameter from 4 to 6 feet. Trunk of tree usually short. An evergreen oak, with rather indistinct annual rings of growth. Heart-wood, light reddish brown; sap-wood thick and somewhat lighter-colored. Wood, hard, heavy, tough, moderately close-grained and very durable in contact with the soil. Little used in construction.

In addition to the above-mentioned oaks of the United States there are the following, which complete the list of all those in any way commercially useful:

18. *Swamp Spanish Oak (Quercus pagodæfolia).* Virginia, south through the Gulf States and up the Mississippi River valley to Illinois. Wood, un-

usually close-grained for one of the black oaks. Color, light reddish brown. One of the largest of the American oaks and the largest and most valuable timber-tree of the region. Valued by lumbermen almost as highly as white oak and used for similar purposes.

19. *Laurel Oak (Quercus laurifolia).* Coast-region, on streams and in swamps, from Virginia to Louisiana. Color, dark brown tinged with red. Wood, heavy, hard, very strong, coarse-grained, liable to check badly in drying. Little used in construction.

20. *Pacific Post Oak (Quercus garryana).* Washington to California. Wood, heavy, strong, hard and tough. Best substitute on the Pacific Coast for eastern white oak. Used for inside finish, furniture, carriages and ship-building.

21. *Valley Oak (Quercus lobata).* Valleys of western California between the Sierra Nevada mountains and the Pacific Ocean. Largest oak tree of the region. Color, light brown. Moderately hard, brittle, fine-grained, difficult to season. Little used in construction.

22. *Arizona White Oak (Quercus arizonica).* Southern Arizona and New Mexico. Color, dark brown or nearly black. Very heavy, hard, strong, close-grained, liable to check badly in drying. Little used in construction.

23. *Emory Oak (Quercus emoriji).* Western Texas, southern Arizona and New Mexico. Color, dark brown or almost black. Very heavy, not hard, strong, brittle, close-grained. Little used in construction.

24. *California Black Oak (Quercus californica).* Western Oregon, southward through California-coast mountains and western slopes of the Sierra Nevada mountains. Color, light red. Heavy, hard, strong, very brittle. Little used in construction.

25. *Durand Oak (Quercus breviloba).* Central Alabama and Mississippi and central and southern Texas. In Mississippi, said to equal the best white oak proper and used, like the latter for similar purposes, such as pins for cotton-gins, spools, etc. In Texas, heavy, hard, strong, brittle, inclined to check and brown in color.

26. *Willow Oak (Quercus phellos).* Along the Atlantic coast from southern New York to Texas and into Tennessee and Kentucky. Color, light brown tinged with red. Wood, heavy and strong, not hard and rather coarse-grained. Sometimes used for construction, clapboards and wheel-fellies.

27. *Shingle Oak (Quercus imbricaria).* From eastern Pennsylvania westward to Kansas and southward to Arkansas. Color, light brown, tinged with red. Wood, heavy, hard, rather coarse-grained, with tendency to check badly. Used occasionally in construction and for shingles and clapboards.

28. *Turkey Oak (Quercus catesbæi).* Atlantic coast from North Carolina to Kansas and southward into Texas. Color, dark, rich brown. Wood, hard, strong and coarse-grained. Little used in construction.

29. *Blackjack Oak (Quercus marilandica).* Southern New York, westward to Kansas and southward into Texas. Color, dark, rich brown. Wood, heavy, hard and strong, with tendency to check badly. Little used in construction.

30. *Scarlet Oak (Quercus coccinea).* Maine, westward to Minnesota and

southward to North Carolina. Color, light or reddish brown. Wood, heavy, hard, strong and coarse-grained. Little used in construction.

31. *Bluejack Oak (Quercus brevifolia).* North Carolina and into Florida and Texas. Color, light brown, tinged with red. Wood, hard, strong, close-grained. Little used in construction.

32. *Blue Oak (Quercus Douglasii).* In California from upper valley of Sacramento River southward along west slope of the Sierra Nevada mountains to the Mohave Desert. Color, dark brown, becoming nearly black when exposed. Wood, heavy, very hard, strong, brittle and inclined to check in drying. Little used in construction.

33. *Pin Oak (Quercus palustris).* Minnesota to Kansas and eastward intermittently to Massachusetts and Virginia. Heavy, hard, strong and inclined to check badly in seasoning. Used for shingles, clapboards, construction, inside finish and cooperage.

34. *Yellow Oak (Quercus velutina).* Sometimes called "black oak." East of longtitute 96 degrees, Maine and Florida, westward intermittently to Minnesota and Texas. Color, bright brown, tinged with red. Wood, heavy, hard, strong, liable to check in drying, not tough, coarse-grained. Used in construction, furniture, cooperage, etc.

61. XI. POPLAR OR COTTONWOOD *(Populus).* These trees are represented on both continents and are among the most widely distributed species of wood; and yet the bulk of the lumber manufactured from them in this country comes from the Central and Southern States. The commercial term "cottonwood" embraces several species, such as the common cottonwood, aspen or popple, large-tooth aspen or poplar, black cottonwood and several other species of minor importance. Though the tulip poplar *(Liriodendron tulipifera)* bears the name "poplar" in many parts of the country, it is a species entirely different from the cottonwood or poplar of Maine or Wisconsin and the two should not be confused. The common commercial "cottonwood" of the East reaches its best development in the South Central States and is cut principally in that region. The wood is often substituted for whitewood but is less desirable.

1. *Poplar* or *Large-tooth Aspen (Populus granditentata).* This tree grows from Maine to Minnesota and southward along the Alleghanies. It reaches a height of from 60 to 80 feet and a diameter of about 2 feet. The wood is soft, light in weight, compact, close-grained and weak. It is little used in construction, but is employed for paper-pulp and occasionally for woodenware.

2. *Cottonwood (Populus deltoides* or *monilifera).* This tree is found from New England to the Rocky Mountains, in the Mississippi Valley, and the West. It furnishes most of the cottonwood of the market. The trees reach a height of from 75 to 100 feet and a diameter of from 4 to 5 feet. The wood is light in weight,

soft, weak, liable to warp, difficult to season, close-grained and compact. It is used for paper-pulp, packing-boxes, fence-boards, etc.

3. *Black Cottonwood (Populus trichocarpa).* This tree grows along the Pacific Coast from Alaska to California and is the largest deciduous tree of the Puget Sound district. It sometimes attains a height of 150 feet and a diameter of from 4 to 6 feet. The wood is light in weight, compact, soft and weak. It is used for woodenware and staves.

There are also two more species that may be mentioned:

4. *Balsam (Populus balsamifera),* called also the "balm of Gilead," growing along the northern boundary of the United States, and the

5. *Aspen (Populus tremuloides),* growing from Maine to Washington and northward, and south in the western mountains to California and New Mexico.

62. XII. SYCAMORE *(Platanus).* The name "sycamore" applies to the buttonball, buttonwood or plane tree in North America. There is an eastern and a western species, the former being commercially important. It is a very useful wood, widely distributed but not occurring in sufficient quantity in any one locality to make a large cut of it practicable. It has an unusually complicated, cross-grained but beautiful structure.

1. *Sycamore, Buttonwood* or *Buttonball (Platinus occidentalis).* This species grows from Maine to Florida and intermittently to Nebraska and Texas and is the one species which is commercially important. The trees reach a height of from 90 to over 100 feet and a diameter of from 6 to (sometimes) 12 feet. Some specimens rank among the largest of American deciduous trees. The greatest production of sycamore lumber is in the central hardwood-states and neighboring Southern States, with Indiana and Missouri leading.

In color the wood varies from white to light brown and in structure it is close-grained and compact with conspicuous satiny, medullary rays. It is very attractive when quartered. The wood is heavy, tough, hard, stiff, difficult to work, not strong, usually cross-grained, hard to split, liable to shrink moderately and to warp and check. It stands well, however, when not exposed. It is used for finishing-lumber, cabinet-work, drawer-backs and bottoms, cooperage, tobacco-boxes, butcher-blocks, ox-yokes, etc.

2. *California Sycamore (Platinus racemosa).* The habitat of this species is California. It is called, also, sycamore, buttonwood, buttonball-tree and buttonball. The trees grow to a height of from 75 to 100 feet and to a diameter of from 3 to 4 feet. The heart-wood is light reddish brown and the sap-wood lighter.

The grain is close, the structure compact, the medullary rays numerous and conspicuous and the surface-appearance is beautiful when the specimens are quartered. The wood is brittle, very difficult to split and to season. Other structural qualities are similar to those of the eastern sycamore and its uses are generally the same.

63. XIII. WALNUT *(Juglans)*. This tree occurs in small, scattered groups over a large portion of the eastern half of the United States, and its finest development is found in the states of the Ohio valley.

"The English or royal walnut *(Juglans regia)*, a native of Persia, was the only available species of this genus until the introduction of the nearly similar black walnut of North America, about the middle of the seventeenth century. As oak gave way first to soft woods for construction, so it gave way first to walnut for cabinet-purposes. The wood soon became very fashionable and exorbitant prices were paid for it. Walnut was extremely popular in the United States until about 1880, when oak began to resume its place as the popular cabinet-wood. The wood of the American species is superior to that of the English or Persian." *

1. *Black Walnut (Juglans nigra)*. This is one of the most widely distributed and valuable of our deciduous trees. It grows from south-western New England to Minnesota and south through the Eastern and Central States. The usual height of the natural tree is from 70 to 90 feet and the diameter from 2½ to 4 feet.

For many years Ohio and Indiana have stood foremost in the production of black-walnut lumber. The total production has remained comparatively steady during the past twenty years, mainly because lumber from this species continues to command a higher price than that manufactured from any other native wood. A considerable quantity is exported to Europe in the form of logs from 10 to 20 feet long and from 15 to 30 inches square in cross-section.

The wood is chocolate-colored, or dark, chocolate-brown which deepens with age and exposure; but its somber, although rich, shade has sometimes been objected to for some positions and uses. The wood is heavy, hard, strong and coarse-textured. It shrinks moderately in drying, and, if care is taken, dries without checking. It works and stands well, takes a good polish and is very durable in contact with the soil, as only the sap-wood decays.

In the earlier days walnut was used even for fence-posts, shingles and the construction of ships. Later, while still fairly abundant, it was used for interior finish, cabinet-work, furniture, gunstocks, tool-handles and carriage-hubs. It has become too scarce to be put to ordinary uses and is now employed largely as a veneer. The

* "The Principal Species of Wood," by Charles Henry Snow.

finer grades have a beautiful figured surface and logs of unusually fine grain bring high prices for veneer-manufacturing.

2. *White Walnut* or *Butternut (Juglans cinerea).* This species is found from New Brunswick to Georgia and westward to Dakota, Arkansas and Texas. The best timbers come from the Ohio River basin. The trees rank as medium-sized, sometimes reaching a height of 75 feet and a diameter of from 2 to 4 feet.

The wood is in many respects similar to that of the black walnut. The color in general is light brown, the heart-wood being light gray-brown, darkening with exposure and the sap-wood being nearly white. The wood is light in weight, quite soft and not strong. It is easily worked and takes a high polish. It is used chiefly for finishing-lumber and cabinet-work.

64. XIV. WHITEWOOD, YELLOW POPLAR or TULIP POPLAR *(Liriodendron tulipifera).* This is known also as the "tulip tree" and "hickory poplar." The trade names "yellow poplar" and "tulip poplar" are used to designate this tree, which is known to the botanists as the "tulip tree" and they have no reference to the true poplars of the genus *Populus,* of which the cottonwoods and aspens are prominent representatives.

The basswood (*Tilia*), poplar or cottonwood (*Populus*), whitewood or tulip-tree wood *(Liriodendron)* and cucumber-tree wood (*Magnolia*) are not botanically related as one genus; but the fact that they are all noted as woods with soft, fine qualities, that they have in general like structural qualities and can be put to the same general uses, has led to the commercial interchanging of these names and of the woods themselves; and this has resulted in considerable confusion.

The whitewood or yellow poplar tree is found from southern New England to the Mississippi River, south to Florida and southwest to Arkansas, Missouri and Mississippi. The manufacture of its lumber is for the most part confined to the Appalachian-Mountain States. Recent government reports affirm that it "is the most valuable lumber in the United States which is produced on a large scale" * and that "during the last few years the highest grades have advanced markedly in price owing to the demand for this class of stock in the manufacture of automobile-bodies." * The maximum production was passed several years ago and the output is steadily decreasing. Tennessee, West Virginia and Kentucky have long been the centers of production.

The tree attains a height of from 90 to 150, sometimes nearly 200 feet, and a diameter of from 6 to 12 feet. The general color of the

* "Lath, Lumber and Shingles, 1909." Forest Products, No. 2, Bureau of the Census, Department of Commerce and Labor, April 11, 1911.

wood is yellowish. The wood is usually light, but varies in weight. It is soft, tough, but not strong and has a fine texture. It is fairly durable when exposed to the weather or in contact with the ground. It shrinks slightly, seasons without injury and works and stands exceedingly well. The sap-wood is thin, light in color and decays rapidly.

With the diminution of the white-pine supply, yellow poplar has been much used in its place. Lumbermen recognize two kinds of poplar timber, white poplar and yellow poplar. Trees growing on dry, gravelly soil produce a wood that is lighter-colored and harder to work and called "white poplar" or "hickory poplar." Those growing in rich alluvial or limestone-soil have a dark-yellow heart-wood which is highly prized because of its fine grain and easy-working qualities.

The wood is used for siding, paneling, interior finish, toys, boxes, furniture, shelving, drawers, culinary woodenware, wagon-boxes, carriage-bodies, slack-staves and heading and backing for veneers. It is in great demand throughout the vehicle and implement-trade and is an ideal wood for the carver and toy-maker.

65. XV. MINOR VARIETIES OF WOODS. In addition to the preceding fourteen divisions or genuses which include those native woods most used in building-construction in the United States, there are several (commercially) minor species which, in addition to being manufactured into lumber in relatively small quantities, are cut, also, into special forms suited to those particular uses for which they are adapted. These twenty-four species may be briefly enumerated as follows:

1. *Red Alder (Alnus oregona).* The wood is light, soft, not strong, brittle, very close-grained, compact, easily worked and takes a beautiful polish. It is reported to be peculiarly adapted to staining and can be made to resemble ebony or mahogany. Cabinet-makers and manufacturers of furniture sometimes work the large knots or burls into pleasing combinations as panels and table-tops. These burls bear some resemblance to those of walnut and are worked in a similar manner. The wood is used principally in the manufacture of furniture, saddles, handles and pulleys.

2. *Apple (Pyrus).* (1) *Crab Apple* or *Fragrant Crab (Pyrus coronaria).* The wood is heavy, close-grained and not hard nor strong. It is used for levers, tool-handles and small domestic articles. (2) *Crab Apple (Pyrus augustifolia).* This is similar in character to *Pyrus coronaria,* but hard and is used for the same purposes. (3) *Oregon Crab Apple (Pyrus rivularis).* The wood is heavy, very close-grained, hard and has a satiny surface which takes a high polish. It is used for mallets, mauls, handles of tools and bearings of machinery.

3. *Boxwood.* The true boxwood *(Buxus sempervirens)* attains to some size in Europe and Asia, but remains a small shrub in America, where it is

seldom if ever cut for wood. American boxwood is derived chiefly from *Dogwood (Cornus florida), Mexican Persimmon (Diospyros texana)* and *Rose Bay* or *Great Laurel (Rhododendron maximum).* Yellowwood *(Schæfferia frutescens),* also, is known as boxwood. (See, also, under dogwood, persimmon and laurel.)

4. *Buckeye* or *Horse Chestnut (Æsculus).* (1) *Ohio Buckeye* or *Fetid Buckeye (Æsculus glabra).* The wood is light, soft, close-grained, not strong, often blemished by dark lines of decay. It is not distinguished commercially from *Æsculus octanda.* It is used for artificial limbs, occasionally for lumber, and for woodenware, paper pulp, etc. (2) *Sweet Buckeye (Æsculus octandra).* The wood is light, soft, close-grained and difficult to split. It is used for the same purposes as *Æsculus glabra.* (3) *California Buckeye (Æsculus californica).* The wood is light, soft, very close-grained and little used in construction.

5. *Catalpa (Catalpa).* The wood of the (1) *Hardy Catalpa (Catalpa speciosa)* is better than that of the (2) *Common Catalpa (Catalpa catalpa).* The wood of the former is light in weight, soft, not strong, elastic, and durable in contact with the soil. It is used for fence-posts and railroad-ties and is adapted for cabinet-work and inside finish.

6. *Coffee Tree (Gymnocladus dioicus).* The wood is heavy, strong, moderately hard, very stiff, of coarse texture and durable in contact with the soil. It shrinks and checks considerably in drying, works and stands well and takes a good polish. It is used to a limited extent in cabinet-work and for posts.

7. *Cucumber Tree* or *Mountain Magnolia (Magnolia acuminata).* The wood is light in weight, soft, not strong, close-grained and durable. It has qualities similar to those of whitewood and has been often sold for that wood. It is used principally for cabinet-making, cheap furniture, flooring, pump-logs, troughs, crates, packing-boxes and other purposes similar to those for which whitewood is used. (See, also, basswood, laurel, poplar and whitewood.)

8. *Dogwood* or *Flowering Dogwood (Cornus florida).* This is called, also, "boxwood." *The Mexican* or *Black Persimmon (Diospyros texana),* and the *Great Laurel (Rhododendron maximum)* afford substitutes. The names "dogwood" and "poison-dogwood" are often applied to the sumach. The wood of the dogwood is heavy, strong, tough and hard and takes a high polish. It is used for wood-carving, engraving, bearings of machinery and turnery. (See, also, boxwood.)

9. *Eucalyptus (Eucalyptus).* The eucalypts are native to Australia and Tasmania but have been planted extensively in California. They are known also, locally, as "gum-trees." The *Blue Gum (Eucalyptus globulus)* is the species commonly referred to when eucalyptus is mentioned in North America. The wood is very hard, strong, heavy, tough and, after it has dried, difficult to split. It is not durable in contact with the soil. It is close-grained and less elastic than hickory. In appearance it closely resembles the woods of hickory and ash.

It is used for wharf-piling and resists the attacks of marine borers longer than other species commonly used. It is not suitable for fence-posts and

telephone-poles on account of its short life when in the ground. It has been manufactured into lumber for use in vehicle-stock, agricultural implements, furniture, cabinet-work, flooring, wood paving, etc.

10. *Hackberry (Celtis occidentalis).* The wood is of medium weight, hardness and strength and is rather elastic. It is not of special importance commercially but is used to some extent in the manufacture of cheap furniture. Its technical qualities resemble those of the elm and white ash and it is occasionally used as a substitute for them. It is not durable in contact with the soil, and, like hickory, when used unpeeled above ground, is likely to become worm-eaten.

11. *Hickory (Hicoria).* Different species are known by different common names, such as "shagbark hickory" or "shellbark hickory," "pignut hickory" (also known as "brown hickory," "black hickory" or "switch-bud hickory"), "mocker-nut hickory" (also known as "black hickory," "bull-nut," "big-bud," etc.), "pecan hickory" (also known as "pecan nut," "pecan tree," "pecan," etc.), etc. The wood is very heavy, hard, strong and proverbially tough and flexible. It is of rather coarse texture, smooth and straight-grained. It dries slowly, shrinks and checks considerably, is not durable in the ground or if exposed, and, especially the sap-wood, is always subject to the inroads of boring insects. It is largely used for carriages and wagon-stock, but is also extensively used in the manufacture of implements and machinery, tool-handles, timber-pins, harness-work, cooperage, wheels, runners, axe-handles, etc.

12. *Holly (Ilex).* The woods of the holly, boxwood and lignum vitæ are often grouped together with reference to the similarity of their general character and uses. They are all used in comparatively small and very perfect pieces and supply needs for which other woods do not appear to be well adapted. The *American Holly (Ilex opaca)*, is noted for its ivory-white color. The wood is of medium weight, hard, tough, not strong, very close and even-grained and of fine, compact texture. It works easily and stands well. It is used for furniture, turnery, scrollwork, and cabinet-work and its color fits it specially for the white of inlaid work, carvings and other decorations where white color and fine qualities are required.

13. *Laurel (Magnolia, Umbellularia, Arbutus, Rhododendron,* etc.). The name "laurel' is given locally or botanically to a number of American plants, several of which grow to the size of trees. (See, also, boxwood, dogwood, cucumber tree, etc.). The wood of the (1) *Big Laurel* or *Magnolia (Magnolia grandiflora)* is suitable for interior finish. The (2) *California Laurel (Umbellularia californica),* called also "mountain laurel" and "myrtle-tree" is close-grained, compact, heavy, hard, strong and takes a beautiful polish. It is used for ship-building, cleats, cross-trees and interior work and Professor Sargent considers it the most valuable cabinet-wood produced by the forests of the Pacific Coast. The (3) *Madrona* or *Madrona Laurel (Arbutus menziessii)* has little place in construction although it has been used for furniture. The wood of the (4) *Great Laurel* or *Rose Bay (Rhododendron maximum)* has been used as boxwood.

14. *Lignum Vitæ (Guaiacum).* The supply is obtained from two species *(Guaiacum sanctum* and *Guaiacum officinale).* The wood of the former is

close-grained, compact, very heavy, exceedingly hard, strong, difficult to work and brittle. It may be lubricated by water. The layers of fibers alternately cross one another so that the wood may be said to crumble rather than to split. No wood is superior to this for implements that must be fine, true and strong, such as the sheaves of pulleys, ship-blocks, rollers, tool-handles and bearings for journals rotating in water. (See, also, under holly and boxwood.)

15. *Locust (Robinia, Gleditsia, Prosopis).* The name "locust" applies to species of three distinct genera, all of which belong, however, to the family *Leguminosæ.* The (1) *Black Locust (Robinia pseudacacia),* is known, also, as "yellow locust" or often simply "locust." The wood is close-grained, compact, very heavy, tough, very hard, strong and very durable in contact with the soil and under extreme conditions of dryness and moisture. It is used for long wooden bolts or pins called "tree-nails," and for fence-posts, ties, building-construction, turnery, ship-ribs, insulator-shanks, wagon-hubs, vehicles, etc.

The (2) *Honey Locust (Gleditsia triacanthos)* has also various local names, such as "sweet locust," "three-thorned acacia," "black locust," etc. The wood is coarse-grained, heavy, hard, tough, strong and fairly durable in contact with the soil. It will take a good polish. It is used chiefly for fence-posts, poles, wagon-hubs and rough construction.

The (3) *Mesquite (Prosopis juliflora)* is called also, locally, "honey locust." The wood is hard, heavy, difficult to work, but weak. It is almost indestructible in exposed positions. It is used locally for posts, fencing, railroad-ties, house-beams, etc.

16. *Magnolia (Magnolia fœtida).* Sometimes called "bull bay." The wood is harder and heavier than the other North American magnolias. It is creamy white in color and well suited to interior finish and cabinet-work. (See cucumber tree and laurel.)

17. *Mulberry (Morus).* The *Red Mulberry (Morus rubra)* has wood which is light in weight, of coarse texture, not strong, rather tough and very durable in contact with the soil. It shrinks and checks considerably in drying but works and stands well and will take a good polish. It is used locally for ship-building and for agricultural implements, fencing and cooperage.

18. *Myrtle Tree.* (See laurel.)

19. *Osage Orange or Bois d' Arc (Maclura aurantiaca* or *Toxylon pomiferum).* The wood of this tree is close-grained, hard, heavy, tough, flexible, and strong. It shrinks in seasoning, is durable in contact with the soil and will receive a beautiful polish. It is used for fence-posts, piles, telegraph-poles and telephone-poles, railroad-ties, paving-blocks, turned ware, wood-carving and occasionally for interior finish.

20. *Persimmon (Diospyros virginiana).* This tree is a member of the ebony family *(Ebenaceæ),* and the extremely close-grained heart-wood is almost black. The ebony of commerce, however, is derived from tropical species of this genus. The wood is very hard and heavy, strong and tough and somewhat resembles hickory, but is of finer texture. It is used for shuttles, plane-stocks, shoe-lasts, etc.

21. *Sassafras (Sassafras officinale* or *Sassafras sassafras).* The wood is light, soft, not strong, brittle and of coarse texture. It checks in drying and is durable in contact with the soil. It is used for cooperage, fence-posts and rails, ox-yokes, skiffs, etc.

22. *Shittim-wood* or *Bearberry (Rhamnus purshiana).* This tree is known as the "coffee tree," "bitter bark," "bearwood" and "wahoo." The wood is light, soft or hard, not strong and of a brownish color tinged with red. The bark of *Rhamnus purshiana* possesses the drastic properties found in that of the other species of the genus. It is a popular domestic remedy in the region in which it grows and under the name of *Cascara sagrada* has been admitted into the American materia medica.

23. *Silver Bell Tree (Mohrodendron carolinum).* The wood is light in weight, soft, close-grained and light brown in color. It grows to a good size in the South Atlantic States but is little used in building-construction.

24. *Willow (Salix).* The *Black Willow (Salix nigra)* is the native commercial species. The wood is close-grained, soft, light in weight, weak, checks badly in drying and works readily. It dents without splitting. It is used for lap-boards, basket-making, fuel and charcoal.

White Willow (Salix alba). This tree was introduced from the eastern hemisphere into the United States very early in the settlement of the country. The common name, "white willow," is also applied to another exotic species, the *Salix fragilis,* similar to the *Salix alba* in form and habits. It is called "crack willow."

The wood of the *Salix alba* is very soft, light, flexible and fairly strong. It is used in slack-cooperage and for cricket-bats and base-ball bats. As it is fairly durable in contact with the soil, it has been generally used, also, for fence-posts on the northwestern plains.

66. IMPORTED WOODS.* The importation of fine hardwoods for interior finish, cabinet-work and other purposes, is increasing constantly in proportion to the growing scarcity and increasing cost of our own forest-products. The commercial development of the tropical and semitropical countries has placed at our disposal an immense supply of valuable woods of utility and beauty, some of which are in great demand. There are many species of good size and commercial possibilities, comparatively unknown to the wood-working trade, but which will be exploited and used to a large extent as they are better understood. Of the imported woods, mahogany, including the substitutes or mahogany-like woods, is the most popular. The annual importation (1912) has grown to an amount which is between forty and fifty million feet, board-measure. It is a wood of great beauty and utility and is the cheapest of all the imported woods. The following are the

* Much valuable data on this subject was furnished by Mr. Fessenden Hall, Philadelphia, Pa., the Otis Manufacturing Company, New Orleans, La., and Uptegrove & Beckwith, New York City, dealers in imported woods, and by the United States Department of Agriculture, Forest Service.

principal woods imported in logs, converted into lumber and veneers and used in the manufacturing of furniture, pianos, cabinet-work and interior finish of all descriptions:

67. I. MAHOGANY (*Swietenia,* etc.). The commercial name "Mahogany" is applied to several genera and species of trees. About forty mahoganies, so-called, are sold in the markets of the world as true mahogany. Among the principal mahogany trees are the Central American or true mahogany (*Swietenia mahagoni*), the African mahogany (*Khaya senegalensis*), the Indian mahogany (*Soymida febrifuga),* etc. There are also minor species called "mahogany," such as the *Rhus integrifolia,* a native of Lower California and the different species of the *Cercocarpus,* of the mountain-regions of Idaho and Arizona. Then there is the so-called "Colombian mahogany" (*Cariniana pyriformis*) from Colombia, the white mahogany or prima vera *(Tabenia donnell-smithii),* the East India mahogany or padouk *(Pterocarpus indicus* and *Pterocarpus dalbergioides),* the so-called "Spanish cedar" or "Mexican cedar" *(Cedrela odorata),* nearly related to true mahogany, etc.

An estimate of the available amount of standing, true mahogany now (1913) to be found in the forests of Mexico and Central America cannot be made without the aid of technical experts who can distinguish true mahogany by its botanical characteristics. At present this information is not possessed by anyone, but the latest and most accurate figures on the amount of mahogany consumed in this country may be obtained from the government reports. Any claim that practically all of the mahogany sold in the United States is genuine is not based upon demonstrable facts.

"The great popularity of true mahogany as a furniture and finishing-wood has caused a steady depletion of the available supply ever since its earliest use, in about 1724. Few users of mahogany realize that the consumption of material passing in the markets as mahogany amounts annually to about 40,000,000 feet, while the cut of real mahogany is only about 18,000,000 feet. This does not mean so much that deliberate deception is being practiced as it does that the demand for true mahogany greatly exceeds the supply. In consequence the producers of mahogany have had to seek substitutes in order to meet the demand. Over twenty mahogany-like woods are now offered as true mahogany, not to mention a considerable number of woods cunningly stained to imitate that wood. While the consumer may derive as much satisfaction from an article of imitation-mahogany as from one made of the genuine wood, the discovery that real mahogany has not been obtained is, nevertheless, ground for just complaint." *

* See "Colombian Mahogany," U. S. Department of Agriculture, Forest Service, Circular No. 185, August 3, 1911.

Mahogany, if we include the substitutes for the real, owing to improvements in getting it out, the employment of large steamers in freighting it to this country and improved methods of manufacturing it, is cheaper than it was in former years and more generally used than ever for furniture and interior finish. Its relative cost is less, owing to the higher cost of quartered oak and other domestic hardwoods. It is practically free from sap, and the heartwood, which shows a deep-pink color when sawed, turns to a rich, brown red on exposure to the light. A large percentage of the wood shows a broken-stripe figure, alternating between light and dark shades. This wood does not fade on exposure to the light, but acquires, with age, a deep, rich, red color. Woods stained to imitate mahogany fade in a few years and present a spotted, streaked, light-brown appearance. Any imitation, therefore, is only temporary.

The mahogany, real or so-called, now used in this country comes from Mexico, Central and South America, the West Indies and Africa, seventy-five per cent of the present supply (1912), coming from Africa. Formerly some mahogany was shipped from San Domingo, but it was never gotten out in large quantities. The wood from this island is almost identical with that from Cuba and is generally harder than that from Mexico and Honduras, although a percentage of Mexican and Honduras wood is indistinguishable from San Domingo wood. The Honduras mahogany was originally termed "baywood" in England, because it was exported from the Bay of Honduras. Although the wood from British Honduras is somewhat lighter in weight and color than that from Cuba and San Domingo, this term is generally used to designate soft and inferior grades imported from the northern part of Mexico. Different mahoganies show marked differences in color, but mahogany from the State of Tabasco, Mexico, is sold in Europe at the same price asked for Cuban mahogany. The mahogany from the State of Tabasco is exported from the ports of Frontera and Laguna.

There is more mahogany now used in solid lumber than ever before, but unusually well-figured logs of large size are "slice-cut" into veneers. When a superior piece of work is required, Tabasco and Honduras mahoganies, of uniform, dark color and hard texture are often specified. African mahogany is not a true mahogany.

When thoroughly dried and glued, there is no wood that stays in place better than mahogany. The wood is strong, brittle, durable, stands well, shrinks little in seasoning and is peculiarly marked with short, straight lines or dashes, by which it can be distinguished from other woods stained to imitate it. It varies with the variety,

from a coarse, loose texture to a close grain and weighs from 3 to 4½ pounds per superficial foot, 1 inch thick, or from 35 to 40 pounds per cubic foot for the hardest and best grades. Mahogany logs are the largest of all those of the imported woods, measuring often six feet in diameter and forty feet in length.

1. *Mahogany (Swietenia mahagoni).* This species comes from Mexico, Central America, the West Indies, the Bahamas, the Florida Keys and South America. The characteristics and uses of the wood are mentioned above. It is the only true mahogany.

2. *Colombian Mahogany (Cariniana pyriformis).* This tree is not related in any way to true mahogany. It derives its name, "Colombian mahogany," from the fact that it is used as a substitute for mahogany and much resembles it in its markings, and from the fact, also, that it comes from Colombia only. It is not known how long the wood has been used in the United States. The trunks of the trees approach the cylindrical in shape, are straight, vary from 24 to 70 inches in diameter and often have a clear length of 50 feet.

"It seems possible now, when the demand for true mahogany is greater than the supply, that there could be an accepted use for such woods as the *Cariniana,* acknowledged to be other than mahogany, but to be so similar to it in color, grain-effects and working-qualities as to serve for the rarer wood. There should be no objection to calling such woods by their proper names. Moreover, unless all good substitutes for mahogany were used, it would be impossible to meet the demand." *

When *Cariniana* is properly seasoned it does not warp, shrink, nor check, while much of the wood is beautifully marked. It works well, but rapidly dulls the mill-saws because of the presence of calcium oxylate, a hard chemical deposit not found in the true mahoganies and Gaboon mahoganies. It takes a filler readily and can be highly polished. It is hard, strong, heavy, weighing 48 pounds per cubic foot, and tough, and in color and weight corresponds almost exactly to genuine mahogany. There is no reason why it should not be employed for all purposes for which true mahogany is used. In many cases the best grades of Colombian mahogany and true mahogany command practically the same market-prices.

3. *White Mahogany* or *Prima vera (Tabenia donnell-smithii).* This tree is found on the west coast of Mexico, in Central America and in South America. It attains a height of from 50 to 75 feet and a diameter of from 2 to 4 feet. The color of the wood is cream-white and the beautiful grain resembles that of the true

* See "Colombian Mahogany," U. S. Department of Agriculture, Forest Service, Circular No. 185, August 3, 1911.

mahogany. It works and stands well and in texture, weight and uses is similar to the latter wood, but higher-priced. The wood of the butternut or white walnut has been sold as white mahogany.

4. *East Indian Mahogany* or *Padouk (Pterocarpus indicus).* This tree is a native of India, Burma and the Andaman Islands. The wood is hard, but works well; has a coarse, open, but dense grain, often filled with a gum-like substance; and takes a fine polish. In weight the wood varies from 5½ to 6 pounds per superficial foot, 1 inch thick. The color varies from light yellow to dark red or deep vermillion, streaked with black, giving a rich, brilliant appearance. Exposure to strong light fades this wood, although when selected for even color, it takes a very fine finish and is almost indistinguishable from genuine mahogany. It is not, however, suitable for furniture as it contains an oil in the fiber and does not glue up well. It was used by the Pullman Company during a period of more than twenty years for the berth-fronts of sleeping-cars. There are a number of banks and office-buildings finished in this wood. It is used principally for interior finish.

5. *African Mahogany (Khaya senegalensis).* A great variety of woods are shipped from Africa under the name "mahogany," none of which is true mahogany *(Swietenia mahagoni).* Its color varies from a pale straw to a deep red and much of it shows many shades of brown. It varies in hardness from a wood as soft and light as white pine to a wood as hard as maple, the softer wood being of a loose, woolly texture while the hardwood is of a more compact and dense nature.

African mahogany has a much larger percentage of "figured wood" than any other variety of mahogany, and, unlike the others, has every type of "figure" common to mahogany. That this wood presents a beautiful appearance and takes a high polish is demonstrated by the fact that a very large percentage of the mahogany veneer is furnished by the African variety. African mahogany is known also as "Gaboon mahogany" or "Lagos mahogany." Gaboon mahogany weighs about 30 pounds per cubic foot.

6. *Spanish Cedar* or *Mexican Cedar (Cedrela odorata).* This tree grows in Mexico, Cuba and the West Indies. It attains a height of from 50 to 80 feet and a diameter of from 2 to 5 feet. It is a broad-leaved tree and not a conifer as the name "cedar" would imply. It is usually found and cut with true Mahogany. The wood is brownish red, straight, even and compact; soft, fragrant, porous and durable. It resembles the cedar woods cut from coniferous trees and also looks like mahogany. It is employed

for fine cabinet-work and may be used in place of mahogany. It is used, also, for cigar-boxes and boats.

68. II. ENGLISH BROWN OAK *(Quercus robur pedunculata* or *robur sessiliflora)*. This is called, also, "British oak." The wood of this tree is of the same general character as our own white oak *(Quercus alba)* except that the color is a clear, rich brown, varying from a light to a deep, rich shade, frequently with a variegated effect. There is little difference between the two species and considerable difficulty in distinguishing between them. The general appearance of the wood is so beautiful and the color so peculiar that it cannot be imitated with any degree of success. The wood is hard, tough, very strong and not easily splintered. It resists the action of water and warps and shrinks in drying. The logs are imported from England, which is apparently the only country in which oak acquires this color; and as the supply is very limited the cost is correspondingly high. The logs are very defective, liable to have cup-shakes and star-shakes and to produce lumber and veneer of small sizes only. The wood is used for cabinet-work and interior finish in the United States and in Great Britain for these and other purposes.

69. III. ROSEWOOD *(Dalbergia nigra)*. This wood is derived from trees which are native to Central and South America and the West Indies. In color the wood varies from dark red to brown, striped with variegated brown and black veins. The grain is coarse and open but dense, the pores being filled with black gum. In weight the wood varies from 5 to 6 pounds per superficial foot, 1 inch thick. Rosewood is best adapted to small cabinet-work details, turnings, musical instruments, veneers, etc. The raw wood has a fragrant odor which disappears when it is varnished.

70. IV. SATINWOOD *(Chloroxylon swictenia)*. This tree grows to a moderate size, is a native of India and Ceylon and belongs to the bead-tree family (*Meliaceæ*). A similar tree, known under the same name, grows in the West Indies and in Europe and is called "Bahama satinwood." It is the wood of the prickly ash (*Xanthoxylon fraxineum*). The wood is hard, of a beautiful light-yellow color and has a rich, silky luster. The grain is close and sometimes mottled. The product of this tree is used in relatively small quantities for veneers, inlay-work and small cabinet-work in general. The satinwood used in the United States comes principally from the West Indies.

71. V. TEAK *(Tectona grandis)*. This tree is native to India, Ceylon, Burma and Siam. It grows to a good size with a straight trunk, often 4 feet in diameter and 100 feet in height. The wood is straight, close and even-grained, of a variable, brownish-

yellow color, moderately hard, strong, easily worked, oily and fragrant. It stands well and resists termites. Its chief virtue is that it may be placed in contact with metal without corroding it. It is imported largely and used principally in the ship-building trades and also for furniture and the backing of armor-plates. The distinct African teak (*Oldfieldia africana*), affords wood sometimes marketed as "African mahogany" or "African oak." The various teaks take their names from the districts producing them.

72. VI. CIRCASSIAN WALNUT (*Juglans regia*).

"Circassian walnut yields one of the best-known and most expensive cabinet-woods in the American and European markets. Botanically, Circassian walnut is the same as the so-called 'English walnut,' the latter name being used almost exclusively by those who grow the tree for its nuts; while the former is the one generally applied to it by manufacturers and other consumers of the wood. Of all the common names given it, English walnut is the least appropriate, because the tree is not a native of England, but was brought there long ago from Asia and cultivated. Obviously, the most appropriate name for the tree is Circassian walnut, since this indicates at once its true origin and natural range. Other names applied to it are 'royal walnut,' 'Italian walnut,' 'European walnut,' 'French walnut,' 'Persian walnut,' 'Austrian walnut,' 'Turkish walnut' and 'Russian walnut.' In Italy the tree is called 'ancona auvergne'; in Persia, 'jaoz,' charmagz' and 'akrot'; in Greece, 'carua,' 'caryon,' 'Persicon' and 'basilikon' (kingly tree); in France, 'noyer'; in Germany, 'englische Wallnuss' and 'gemeine (common) Wallnus'; in Spain and Cuba, 'nogal'; in South America, 'nogal,' 'nogal America' and 'nogal comun'." *

Adapted to a wide range of soils and climatic conditions, Circassian walnut is one of the most widely distributed of the commercial timber-trees. It is native to the eastern slopes of the Caucasus and extends eastward along the valleys and slopes of the Hindoo Koosh to the southern foothills of the Himalayan Mountains, where it is said to form large, pure forests. From there it extends southward to northern India and into Burma. It is probable that the species reaches its best development in the Caucasus Mountains. It has been widely planted in Europe and the United States but it is not known when it was first introduced into this country. It is grown here principally for its nuts, particularly on the Pacific Coast; but the wood grown in the United States is not manufactured into lumber to any great extent.

Probably no other wood has served so many purposes as Circassian walnut. Long before the discovery of America it was the most popular of woods for furniture and interior finish and later

* Extract from "Circassian Walnut," U. S. Department of Agriculture, Forest Service, Circular No. 212, January 25, 1913.

for many other purposes, particularly gun-stocks. In Southern Europe it is still used locally for all grades of furniture. Its present high cost, however, prohibits its use in this country for any but the very finest furniture and cabinet-work. The wood of old trees is prized on account of its dark color and beautiful veining, strength, lightness and elasticity. When unusually well marked it is one of the most attractive and valuable of the veneer-woods, particularly for furniture, the best grades often bringing a higher price than mahogany, especially in the United States. The average price paid for logs at shipping-ports is from $80 to $100 a ton, or a little more than 4 cents a pound. Single trees containing choice burls, crotches or fine bird's-eye effects have sold for over $3,000. This high price is caused by the great difficulties of logging and transportation to shipping-ports. The wood is so heavy when green that it sinks in water, and cannot, therefore, be floated, but must be hauled over bad roads to the place of shipment. Most of the Circassian walnut now used comes from the shores of the Black Sea and from other regions as far east as Persia and India.

The United States is believed to be the greatest consumer of Circassian walnut, especially of the highly figured grades. During 1911 the consumption was about 2,500,000 board-feet, Maryland and Michigan leading in its use.

Unlike most other saw-timbers the straighter and better-formed trees do not yield the most highly prized quality of lumber. It is usually the crooked, irregular logs that supply the most beautifully figured wood, such logs being valued according to the amount of lumber they yield.

Circassian walnut weighs about 45 pounds per cubic foot, is hard and compact, easily worked and split, moderately tough and durable in contact with the soil. It shrinks very little in seasoning and does not crack or warp. The sap-wood is a pale fawn-color or almost white. The heart-wood is a dark chocolate-brown, often shading from light brown to black. Burled and other highly figured forms of the wood take a beautiful polish. The wood of trees grown in poor upland and hilly soils has a beautiful fine grain and texture, while that grown in rich lowland-soils is much coarser and less beautifully marked. The best qualities of timber are obtained from vigorous trees over 100 years old, which rarely have a clear length of more than 12 feet. The most beautifully veined wood is in the roots and burls.

Although it is usually easy for expert buyers to recognize true Circassian walnut in the logs, it is often difficult to distinguish the wood from some of its substitutes when the latter have been skillfully stained and finished. There are many good African, Asian

and South American woods which are similar in structural qualities to Circassian walnut, but none possesses the magnificent figure, delicate tones and velvety texture of the true Circassian walnut. Chief among these is the so-called "satin walnut," "tassel wood," or red gum (*Liquidambar styraciflua*) of the United States, which has been sold as Circassian walnut for furniture and for interior finish. Our native cotton gum (*Nyssa aquatica*) is another wood occasionally sold as Circassian walnut. Other possible substitutes among the true walnuts and related woods are, Caucasian walnut (*Pterocarya caucasia* or *Pterocarya fraxinifolia*), Japanese pterocarya or sawa-gurumi (*Pterocarya rhoifolia*), butternut (*Juglans cinerea*), Jamaican or West Indian walnut (*Juglans insularis*) and nogal (*Juglans australis*).

73. VII. BURLS. "Burl" is the name given to the wood obtained from large excrescences or "burrs" found on many trees of the walnut family in all parts of Europe, but principally on those growing in the region of the Black Sea and in Italy. The grain in such growths is beautifully irregular and much prized for veneers.

74. VIII. MISCELLANEOUS IMPORTED WOODS. Besides the imported woods above enumerated, there are varying quantities of Boxwood, Cocobolo, Lignumvitæ, Lancewood, Philippine Walnut and many others, imported for cabinet-work, mechanical purposes, turnings, etc.

75. VENEERS. There is a long list of domestic and foreign woods which are used for veneers, built-up-veneer panels, etc. The following is a list of woods, with their commercial names, kept in stock for these purposes, by one firm: *

Ash, brown	Mahogany, Honduras
Ash, white	Mahogany, Mexican
Basswood, Wisconsin	Mahogany, white
Birch, curly	Maple, bird's-eye
Birch, red	Maple, plain white
Birch, white	Oak, plain red
Cedar	Oak, plain white
Cherry	Oak, sliced-cut, quartered
Chestnut	Pine, white
Gum, Red	Pine, yellow
Cypress	Poplar
Mahogany, African	Sycamore
Mahogany, crotch	Teak
Mahogany, Cuban	Walnut, American
Mahogany, East Indian	Walnut, Circassian
Mahogany, Gaboon	Walnut, Philippine.

* Furnished by the American Veneer Company, Kenilworth, Union County, N. J.

The development of the veneer-industry follows logically the growing scarcity and increasing cost of timber, as a result of which, economy in the use of wood is being practiced in many ways, one way being the substitution of thin for thick lumber. Veneers were formerly manufactured from the cabinet-woods exclusively and their use was confined to the covering of inferior woods. But while this class of veneers still forms an important part of the total product of the industry, by far the larger and more rapidly increasing part is made up of veneers manufactured from inferior hardwoods and a few of the conifers and utilized as material in the manufacture of "built-up" lumber, packing-boxes, crates, barrels, baskets, etc.

Veneers are prepared by three processes: (1) rotary cutting, (2) sawing and (3) slicing. The first-named process (1), is the one most extensively used, especially in the case of the cheaper woods, while (2) sawing and (3) slicing are the methods generally employed in manufacturing veneers from the more expensive cabinet-woods. In the case of birds-eye maple and curly birch, however, the peculiar figure in the grain is best shown in tangential section, and the rotary cutting is the process usually employed.

The making of veneers is, in general, confined to sections of the country where suitable timber abounds and the kind of timber most used in each State depends, in a measure, upon the prevailing species there. Thus red gum is the principal timber used in Arkansas, Illinois, Kentucky, Missouri, Tennessee and Texas, in which States this wood is plentiful; yellow pine is the material principally used in Florida and Georgia; maple in Michigan, New York and Pennsylvania; birch in Vermont and Wisconsin; and oak in Indiana.

Several states, noticeably Indiana, Michigan, New York and Ohio, cover a wide range of woods in the manufacture of veneers, due largely, especially in the case of New York, to the utilization of timber from other States and of imported woods.

The thickness of most of the (1) rotary-cut veneers are multiples of 1/16 of an inch. The amount of timber used for veneers 1/8 and 3/16 of an inch in thickness forms from thirty to forty per cent of the total amount manufactured by this process. The (2) sawed or (3) sliced veneers are, in general, thinner than the (1) rotary-cut veneers. This is shown by the fact that in the case of the last-named process (1), the largest amount of material used in recent years in making any one thickness has been for the 3/16-inch stock, while for the other two processes, (2) and (3), the greatest amount has been used for the 1/20-inch stock.

The following are the thicknesses of veneers, in fractions of an inch, made by the (1) rotary-cut process: 5/16 and over, 1/4, 7/32, 1/5, 3/16, 1/6, 5/32, 1/7, 1/8,

1/9, 1/10, 3/32, 1/11, 5/68, 1/12, 1/13, 1/14, 1/15, 1/16, 1/18, 1/20, 1/21, 1/22, 1/24, 1/25, 1/26, 1/28, 1/30, 1/32, 1/34, 1/35, 1/36, 1/40.

The following are the thicknesses of veneers in fractions of an inch, made by the (2) sawing or (3) slicing process 5/16 and over, 1/4, 7/32, 1/5, 3/16, 1/6, 5/32, 1/7, 1/8, 1/10, 1/12, 1/15, 1/16, 1/18, 1/20, 1/22, 1/23, 1/24, 1/28, 1/29, 1/30, 1/32, 1/36, 1/40, 1/100, 1/110, 1/120, 1/140.

The following is a list of woods reported (1908) to be manufactured into veneers, and taken from recent government publications.* The woods are enumerated about in the order of the amounts of timber consumed, beginning with the largest amount. Of course this order and the amounts change from year to year:

Domestic Woods.

1. Red gum	12. Red oak	23. Magnolia
2. Yellow pine	13. Spruce	24. White pine
3. Maple	14. Walnut	25. Buckeye (Horse Chestnut)
4. Yellow poplar	15. Sycamore	
5. Cottonwood	16. Ash	26. Balsam fir
6. White oak	17. Douglas fir	27. Hickory
7. Birch	18. Sugar pine	28. Cypress
8. Tupelo	19. Chestnut	29. Cedar
9. Elm	20. Tamarack	30. Larch
10. Basswood	21. Western pine	31. Holly
11. Beech	22. Hemlock	32. Cherry

Imported Woods.

1. Mahogany	3. Maple	5. Beech
2. Spanish cedar	4. Birch	6. Circassian walnut.
	7. Satinwood.	

Very small amounts are reported also from a number of other woods. (See, also, Art. 235, Chap V.)

76. MARKET PRICES OF WOODS. The price of woods of all kinds varies not only with the locality but also with the conditions of business which affect the demand. The average "mill-value" of lumber of different kinds varies from year to year; but it may be said that, with the exception of a drop in values following a business-depression, the tendency is for the average value to steadily increase. For example, lumber-values advanced considerably between 1899 and 1907. The average mill-value of all kinds of lumber in 1899, amounting to $11.13 per thousand feet, was less than that of the cheapest lumber reported in 1910, while the average amount paid for lumber at the mill in 1910, namely, $15.30, would

* "Forest Products of the United States," Department of Commerce and Labor, Bureau of the Census, 1908.

have been more than sufficient in 1899 to purchase at mill-values nearly any commercial wood cut in the United States, except walnut and hickory.

The spruce and hemlock-manufacturers and the Pacific-Coast lumbermen appear to have practically uniform prices for their woods. For cypress and certain varieties of pine there appear to be fairly uniform prices also; but for practically all hardwoods, such as ash, basswood, birch, chestnut, gum, hickory, oak, poplar, etc., there seems to be no uniform range of prices. Even for cypress, hemlock, pine and spruce there are so many mills outside the large groups of lumber-manufacturers, that a considerable range of prices obtains at all times and there is always a healthy competition. For example, genuine red cypress, well manufactured and from mills operating in the same section as that in which some of the largest cypress-mills operate, may be bought and sold in New York at prices equal to those of the larger manufacturers and in many cases below their figures.

The following prices should be considered as comparative, although they represent, generally, correct average values in many cases. They are the average prices at which carpenters or other consumers of woods can buy them in small quantities at the yards. The retail-yards usually add about 25 per cent to the wholesale-price. The yards generally keep lumber on hand some time, getting it into good condition for working or kiln-drying it, and they generally figure about 15 per cent expense and 10 per cent profit, or a total of 25 per cent, in passing it on to the user.

The figures for the hardwoods include quite a range and are supposed to include the various grades of such woods. Of course a complete list would require at least a page for each of the several woods in order to include the prices for the various thicknesses and grades and also for the extra lengths. This would be beyond the scope of this article, which is to give an approximate idea, only, of the retail market-prices of several kinds of woods largely used in building-construction and finish.

Framing-timber. For medium sizes, per thousand feet, in lengths not over 16 feet: hemlock, $27, New York; $22, Chicago; spruce, $30, New York. For large sizes, in lengths over 16 feet, from $2 to $4 a thousand more.

Long-leaf yellow pine: $30 to $31, New York; $32 to $33, Boston; $28 to $30, Philadelphia; $26, Chicago; $30, Kansas City; $35, Denver; and $20 to $30, New Orleans.

Outside Finish. White pine: $30 to $120 per thousand, according to quality; $75, average for Chicago.

Whitewood or yellow poplar, east of the Rocky Mountains: from $30 to $75.

Cypress: $30 to $60, New Orleans.

Redwood boards, best quality: $50, per thousand, Denver.

Framing-timber and inside finish, San Francisco, Cal. Douglas fir, for framing-timber, medium lengths, $17 per thousand feet; Douglas fir for finish-work, not kiln-dried, $40; redwood, rough, common, up to 20 feet in length, $24; redwood, clear, up to 20 feet in length, $35; spruce, common, $20; spruce, milled and clear, $45; sugar pine, clean, 1 inch by 12 inches, $87, milled, $90; cedar, 1 inch by 12 inches, clear and milled, $70; redwood boards, best quality, milled, not kiln-dried, $45.

Framing-timber and inside finish, New Orleans, La. Pine framing, (if long-leaf pin is insistd upon, add about $2 per thousand): 2 by 4, 2 by 6, 2 by 8 and 2 by 10 inches, up to 20 feet in length, $18 to $24; 3 by 4, 4 by 6 and 6 by 8-inch sizes of above, about the same price; for 12-inch sizes, add $2 per thousand and $1 per thousand for each inch over 12 inches; add $1 per lineal foot per thousand for lengths over 20 feet; floorings and ceilings, $26, $31 and $45.

The above applies to the ordinary "house-bill." For "A" grade, or practically perfect stock of any of the material referred to, the price varies, but runs from $35 to $58 per thousand feet.

Cypress framing is little used and the price runs 25 per cent more than for the same dimensions in pine. Cypress-finish stock: this varies from $25 for stock that will cut about 50 per cent fair material, to $60 for perfect cornice or interior-finish material. For widths over 12 inches add $5 per inch per thousand.

Inside finish. Hardwood, New York prices: mahogany, 14 to 18 cents per foot; white mahogany, 18 to 20 cents; red birch, 3 to 6 cents; cherry, 8 to 12 cents; oak, quartered, 6 to 11 cents; black walnut, 6 to 12 cents; maple, 3 to 5 cents; ash, 3½ to 8 cents; English brown oak, imported, satinwood, and Circassian walnut, about 50 cents per square foot each.

Hardwoods, San Francisco prices: mahogany, 25; oak, quartered, 14; ash, 13; red birch, 13; eastern red gum, 13 cents per square foot. Hardwood prices are practically uniform along the Pacific Coast, as at present all hardwoods have to be imported from the East. California, however, will soon be placing on the market a supply of eucalyptus.

CHAPTER II.

Wooden Framing. Ordinary Construction.

1. FRAMING-DRAWINGS AND FRAMING-TIMBER.

77. RELATION OF DRAWINGS TO WORK. Although it is not necessary for the architect, draughtsman or superintendent to be able to lay out the frame of a building, cut the timber and put it together, it is necessary for him to know thoroughly how these things should be done and how all the joints or connections should be made, as otherwise he can not be sure that the work is being properly executed.

In the Eastern States it is the custom of some architects to show the complete framing of wooden buildings by a separate set of drawings, and to make separate framing-plans for the floors and roofs of brick buildings; but in the West the framing is often left to the care of the builder, the sizes of the timber being specified and the direction the floor-joists are to run being indicated by dotted lines on the plans. The use of this latter method should be discouraged, as it is much better for all concerned to have a complete set of framing-plans furnished by the architect.

The young practitioner should bear in mind also, that the courts invariably hold the architect responsible for the safety of the building, as far as it depends upon the plans and specifications, and, therefore, that nothing of importance should be left to the discretion of the contractor, unless perchance he is one in which the utmost confidence may be placed.

78. FRAMING-TIMBER. *Technical Terms.* To design the framing of a building in a practical and economical manner, it is necessary for the architect or draughtsman to be familiar with the kinds of wood used for framing in the locality in which the building is to be constructed, with their relative cost, and also with the commercial sizes to which lumber is sawed. Information on these points is given in Arts. 20, 28, 29 and 76, but it should be supplemented by inquiries of local contractors or lumber-merchants.

The various pieces of timber used in framing buildings have distinguishing names with which, also, it is necessary to be familiar.

Thus the small beams which directly support the flooring are often called "joists," * the pieces which support the roof-boarding are called "rafters" and the uprights in a wooden wall or partition, "studding" or "studs." Beams which support the floor-joists between walls or partitions are called "girders," and similar beams under the rafters of a pitched roof are called "purlins." Small timbers, the cross-sections of which are 2 by 4, 2 by 6, 3 by 4, 4 by 4 inches, etc., are sometimes called "scantlings." Pieces 4 by 6 inches and over in cross-section are almost always called "timbers."

There are various other names, also, for timbers used in special positions, which will be mentioned in describing the construction of which they form a part. (See, also, Arts. 20, 22, 28, 29, 79 and 102, etc.)

79. FRAMING-TIMBER. *Sizes.* Floor-joists, rafters and studs are commonly made 2 inches thick, the depth depending upon the span of the joists or rafters and upon the height of the studding.

As the strength of a rectangular beam varies directly as the *square of the depth* and only directly as the breadth, a deep beam is more economical of material than a thick one. Thus, for the same span, a 2 by 10-inch joist has about the same strength as a 3 by 8-inch or 5½ by 6-inch beam; but it contains less lumber. The deeper beam is also much stiffer, the stiffness varying directly as the *cube of the depth;* so that a 2 by 10-inch joist and a 3⅞ by 8-inch beam have about the same stiffness, other conditions being equal, although the latter contains 55 per cent more lumber than the former. When the depth of a joist exceeds 12 inches, however, the thickness should be increased to 2½ or 3 inches, as a 2 by 14-inch joist is liable to fail by buckling sidewise.

Large timbers are generally made more nearly square in cross-section, for the reason that it is difficult in most woods to get a great depth with a 6 or 8-inch thickness. Hence, for girders and purlins, 8 by 10, 10 by 12 and 12 by 14 inches are common sizes; and 16 by 20, 18 by 22, 20 by 24-inch, etc., and several sizes of square timbers are sometimes used in heavy construction, although the larger timbers, except in Douglas fir, are difficult to obtain in long lengths. Posts, on the other hand, should be either circular or as nearly square in cross-section as the conditions will permit, posts with a square cross-section being the most economical for timber. (See, also, Arts. 20, 22, 28, 29, 78, etc.)

* The New York City and some other Building Laws do not use the term "joists." All secondary timbers supporting flooring are called "floor-beams."

2. OUTSIDE WALLS OF WOODEN BUILDINGS.*

80. THE BRACED OR FULL FRAME. In the framing of the walls of wooden buildings, three methods may be followed: (1) the braced frame or full frame, (2) the balloon frame and (3) the combination frame. The first is sometimes described as the "old-fashioned framing."

The braced frame or "full frame," as it is sometimes called, was the only kind in vogue previous to about the year 1850. In this method of framing, the sills, posts, girts and plates are made of heavy timbers, all mortised and pinned together and also braced by 4 by 4 or 4 by 6-inch timbers, mortised and pinned to posts, sills and girts. The common studding is also mortised to the sills, girts and plates. To frame a building in this way it is necessary to make all the mortise-holes and to cut all the pieces while the latter are on the ground, and then, after they are fitted together, to raise a whole side or at least one story of it, at one operation.

In colonial days the posts and girts were often made of hewn timbers 8 and 10 inches square in cross-section, so that they projected into the rooms; and it required a great many men to raise the walls when the fitting was completed.

The braced frame, when carefully fitted and pinned, is very substantial and is much more slow-burning than the balloon frame. Vermin cannot go through the walls from one story to another. It is also very difficult to "rack" such a frame; and unless all posts are plumb and parallel the braces will not fit.

Fig. 29 † is a typical braced frame, "mortise-and-tenon frame" or "full frame," shown in section, isometric perspective and elevation. Fig. 30 ‡ shows another type of braced frame in which the ledger-board, ribbon or false girt is used for the upper tier of joists. This illustration shows, also, the relation between the wall-framing and the floor-construction, the lath and plaster, window-frames, casings, ceiling-furring, base-board, outside sheathing, brick fire-stop, etc. The frame is shown in isometric perspective, looking out; in elevation from the outside; and in section.

81. THE BALLOON FRAME. In this method the frame is composed of much lighter pieces, is more quickly erected and costs

* See, also, Arts. 334 to 336, Chap. VI, for nails, spikes, bolts, etc., used.

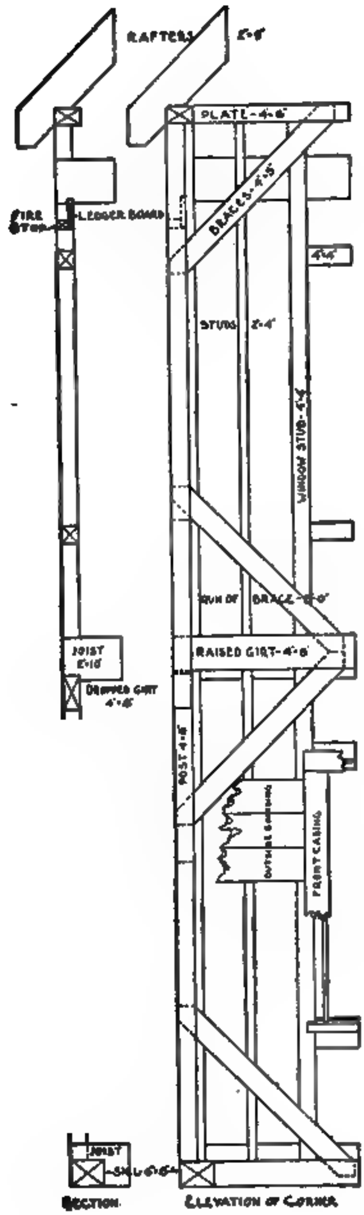
† The drawings for this and for several other figures illustrating approved methods of carpentry-construction were adapted by permission from the set of plates designed by Professor Charles P. Warren of Columbia University.

‡ The drawings for this and for several other figures illustrating approved methods of carpentry-construction were adapted by permission from the set of plates, entitled "Constuction Details," designed by Professor F. W. Chandler, of the Massachusetts Institute of Technology.

less than the braced frame. The method of procedure in erecting a balloon frame is first to lay the sill, which is generally 4 by 6 inches, in section, halved together at the angles. After the floor is laid,

Fig. 29. Braced Frame.

the corner-posts, which are generally 4 by 6 inches, although sometimes 4 by 4 inches, are set up and secured temporarily in place by means of "stay-laths," or pieces of boards nailed diagonally to posts and sills. The common or filling-in studds are then set up, with



ISOMETRIC VIEW

Fig. 30. Braced Frame.

their lower ends spiked to the sills, and stayed in place by boards temporarily nailed across them on the inside. The filling-in studs extend the whole height from sills to plates, and the outside ends of the second-floor joists are supported on 1 by 7-inch boards, called "false girts" or "ribbons," notched into the inside faces of the studs at the proper height. The ends of the joists are also placed against the studs, whenever practicable, and spiked to them.

After the second-story flooring is framed the upper ends of the studs are cut to a horizontal line and a 2 by 4-inch piece spiked on top, and then another 2 by 4-inch piece on top of that, the two pieces always breaking joint. If the common studs come in lengths that will not reach to the plates they are sometimes spliced out with short pieces set on top of the short lengths and the joints are "fished" by nailing short boards on two sides.

Fig. 31. Balloon Frame.

Fig. 31 shows a portion of the framework of a two-story house constructed in the manner described above. In the better class of buildings the frame is braced at the corners by means of 1 by 6-inch boards, let in flush on the outside of the studding and nailed at each intersection with two or three tenpenny nails, as shown in the figure. In many cheap buildings these braces are omitted, but unless the sheathing is put on diagonally they should always be used. In the balloon frame the timbers are held together entirely by nails and spikes, thus permitting the frame to be rapidly put up. For the timbers and studding thirtypenny and twenty-penny spikes should be used, and for the 1-inch stuff tenpenny nails. Cut nails are to be preferred, as they hold better than wire nails.

In both methods of framing the studding is doubled on each side of the window and door-openings. In the balloon frame it is necessary to have the double studs extend the full height of the wall, and

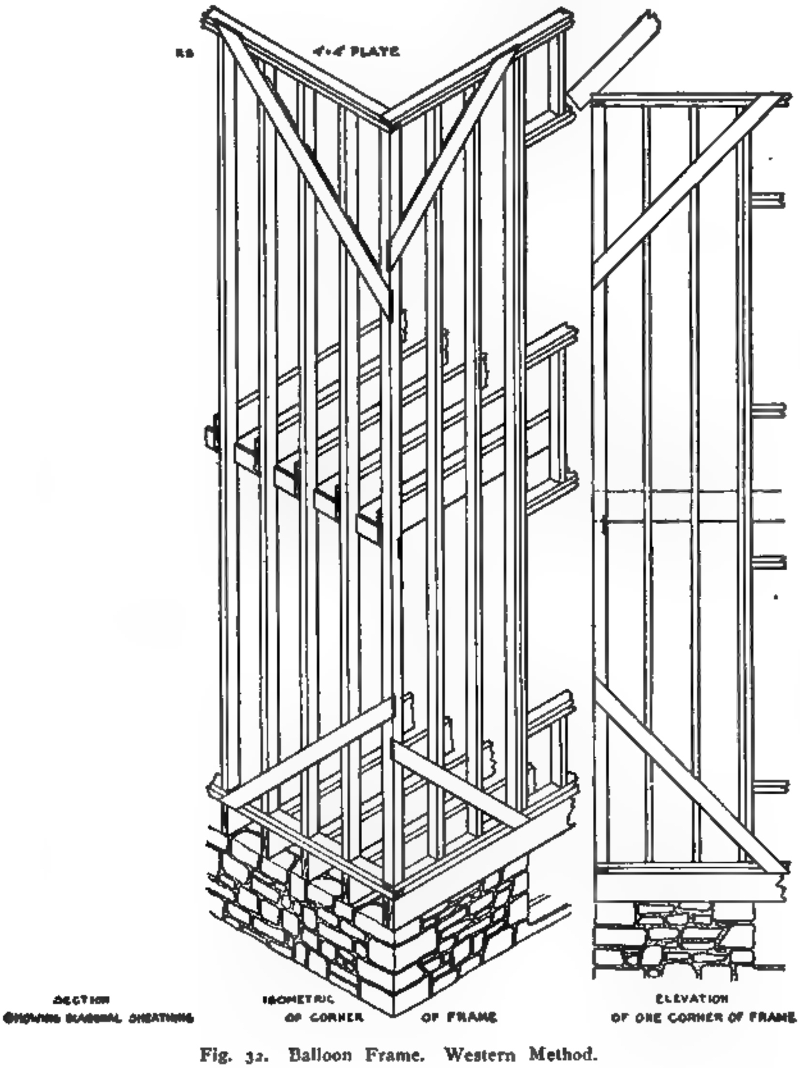


Fig. 32. Balloon Frame. Western Method.

hence it is desirable to have the windows in the second story directly over those in the first story. In the braced or full frame, however, the common studs extend the height of one story only, and the location of an opening, therefore, affects the construction but little.

The balloon frame is much cheaper than the braced frame; and as it is concealed when the house is sheathed and plastered, balloon framing is generally employed for houses built to sell, and is the

SECTION SHOWING DIAGONAL SHEATHING ISOMETRIC OF CORNER OF FRAME ELEVATION

Fig. 33. Balloon Frame. New England Method.

method in vogue in many parts of the United States, especially in the Northwest. A frame of this kind, however, is less rigid than the braced frame and is more quickly consumed by fire.

Fig. 32 shows a method of balloon framing much used in the Western States. The frame is composed of small timbers, nothing larger than 2 by 4 inches in cross-section being used for the uprights, and all being spiked together without special framing. The studs run from sill to plate and are toe-nailed to both. The sills rest on the joists. In the best examples the braces are notched in at the corners as shown. The sheathing is put on diagonally in all

Fig. 34. Combination Frame.

cases. The drawings shown in Fig. 32 include an isometric perspective of the corner, viewed from the outside; an outside elevation; and a section and elevation from the inside, showing the diagonal sheathing. Fig. 33 shows the New England method of balloon framing. This differs from the Western method in that the sills, posts and plates are of dimension timbers. In all other respects it is the same. It differs from the frame shown in Fig. 31 in the manner of corner-bracing, formation of plates, etc.

82. THE COMBINATION FRAME. The better class of wooden buildings are now framed by combining the balloon and the braced or full-frame methods. The braced frame is adopted as far as the sills, posts, girts and braces are concerned, but the common

Fig. 35. Detail of Combination Balloon and Braced Frame.

studding is generally mortised at the lower end only and spiked at the upper end, and the plate is generally made of two thicknesses of 2 by 4 or 2 by 6-inch planks spiked to the top of the studding and breaking joint.

An example of this method of framing is shown in Figs. 34 and

35, which were taken from the framing-drawings of a building erected in the suburbs of Boston.

Within the limits of that city (outside of the fire-limits) this method of framing was formerly required by law. The building ordinance now reads:

Every wooden building hereafter erected or altered shall have all its parts of sufficient strength to carry the weight of the superstructure; shall be built with sills, posts, girts, studs and plates, properly framed, mortised, tenoned, braced and pinned in each story; or with a balloon frame. The posts and girts shall be not less than 4 by 6 inches in cross-section, and the studs shall be not more than 20 inches apart.

The balloon frame is now allowed, but in the opinion of the author the combination or braced frame should be employed for all large buildings and for the better class of dwellings.

3. FRAMING-DETAILS AND DIMENSIONS.*

83. SILLS. Where the sills rest on brick or stone walls, and the cellar-openings are narrow, a 6 by 6-inch sill answers very well; but if the sills rest on posts, or if there are wide openings beneath, they must have sufficient strength to support the walls and floors above the openings. It should be remembered, also, that in this method of framing a good deal of the sill is cut away by mortising, as shown in Fig. 36, thereby greatly lessening its strength. In all large or heavy buildings the sill should be at least 6 by 8 inches and laid with the broad side on the wall.

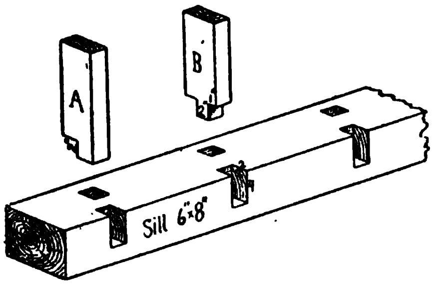


Fig. 36. Mortising Sills for Studs.

The sills should always be imbedded in cement mortar and should be set in, at least 1 inch, from the outside face of the wall. They should be halved and pinned at the angles † and wherever splices occur, but when practicable they should be in one length from angle to angle; and they should, of course, extend all around the house. In commencing the frame of a wooden building the sills are the first timbers to be cut and put in place.

If the basement is 5 feet or more above grade, the sills should be bolted to the masonry with ⅞-inch bolts 30 inches in length.

* See, also, Arts. 20 and 22, Chap. I.

† In New England the sills are often mortised and tenoned at the angles, but it is doubtful if any particular advantage is gained thereby unless the sills are very large.

These bolts should be solidly bedded in the wall, extended through the sill and each furnished with a nut turned up tight. The sills of buildings of which the first story is of brick or stone should be secured in the same way.

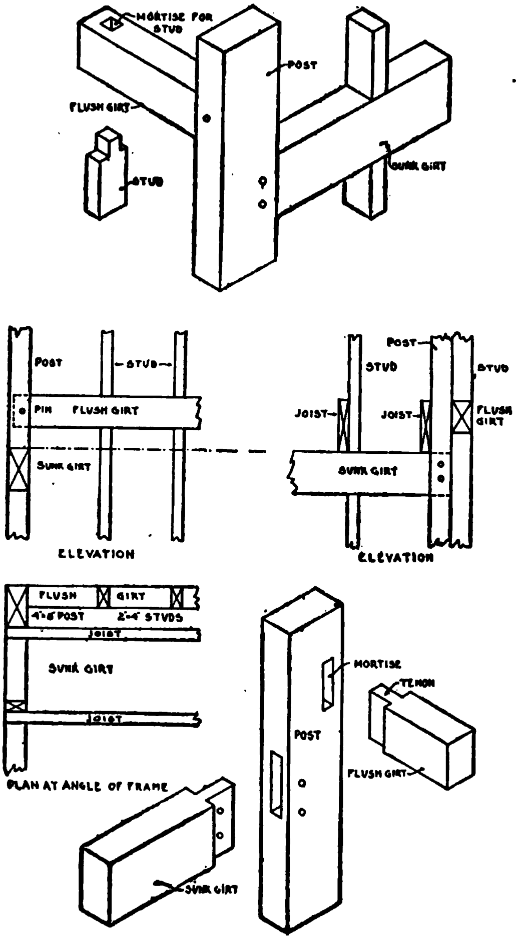


Fig. 37. Posts and Girts.

84. STUDDING. For frame buildings of medium size 2 by 4-inch studding is almost invariably used; for frame churches, schools, commencing the frame of a wooden building the sills are the first etc., 2 by 5 or 2 by 6-inch studding should be used. In the cheaper class of buildings the studs are generally set 16 inches on centers,

but a much better building is obtained if the spacing is made 12 inches. All studs for buildings that are to be plastered should be sized to a uniform width by passing them through a planer. The lower end of the studs should be mortised into the sills, as shown at *A* or at *B*, Fig. 36. The latter method is the better of the two and should always be used for 5-inch or 6-inch studding.

85. POSTS, GIRTS AND BRACES. One dimension of these pieces is always governed by the width of the studding. When 4-

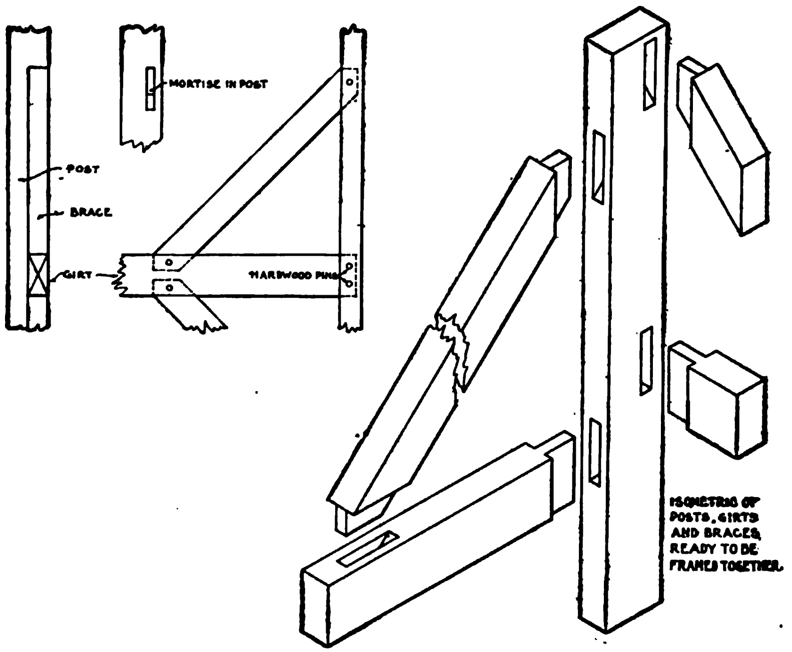


Fig. 38. Posts, Girts and Braces.

inch studding is used the posts may be 4 by 6 or 4 by 8 inches, the girts 4 by 8 inches and the braces 3 by 4 inches in cross-section. For wider studding the thickness of the posts and girts must be the same as the width of the studding. The posts at interior angles should always be 2 inches wider in one dimension than in the other to leave nailing-space for the sheathing.

Figs. 37 and 38 show various details of the framing of posts and girts in a braced-frame construction. Fig. 39 shows the plan, elevation and isometric perspective of the ledger-board or false girt used with the balloon frame. The joists should be notched over the ledger-board as shown, but this detail is often omitted.

The connection of the girts with the posts should be made as shown in Fig. 40, and the braces should be mortised and pinned as shown in Fig. 41. although they are too often merely spiked. All

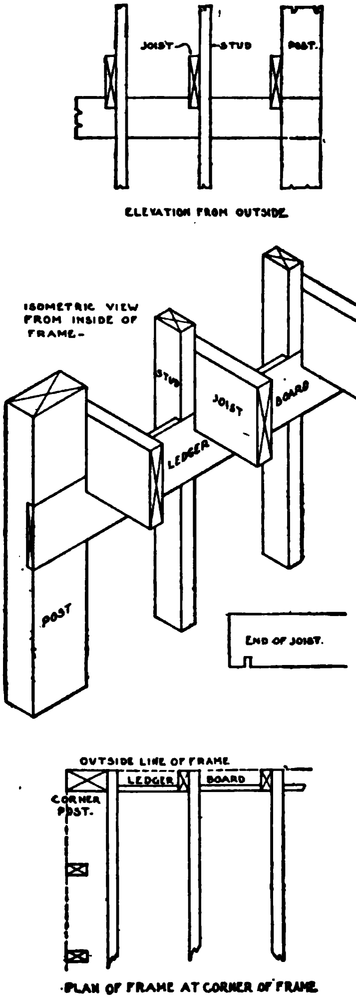


Fig. 39. Ledger-Board or False Girt. Balloon-Frame Construction.

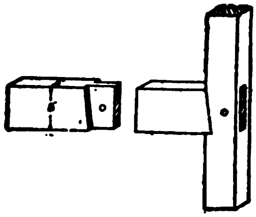


Fig. 40. Connection of Girt with Post.

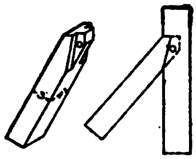


Fig. 41. Connection of Brace with Post.

pins used in framing should be made of some hardwood and should be ⅞ of an inch in diameter for girts and ¾ of an inch for braces.

When the attic-floor joists come a short distance below the plates they are usually supported on 1 by 7-inch boards, called "ledger-boards," "ribbons" or "false girts," let into the studding as shown in Fig. 35. When there is a wide opening in the second story, however, a solid girt must be substituted, as shown in Fig. 34, to provide sufficient strength to support the floor and roof. Where there is room, it is advisable to truss over all openings exceeding 4 feet in width.

86. PLATES. If the attic joists rest on top of the plate, the latter cannot be wider than the studs unless it projects on the out-

side; but if the plate is above the attic joists, as in Fig. 35, a wider plate may be used, as for example, a 4 by 6-inch plate. The wider the plate the greater the resistance offered to the thrust of the rafters and to the consequent springing of the wall. Whatever size is used, it is better to build up the plate with pieces 2 inches thick, spiked together, rather than to use solid timber, as a built-up plate warps or twists less, can be more strongly spiked and have its joints more firmly spliced. (See, also, Figs. 238, 239, 243 to 246, 253, 255, 259 to 261, 264, 266 and 268.)

87. FRAMING-DRAWINGS. The framing of the outside walls of a wooden building is generally indicated by a set of elevation-drawings showing each side of the building in the manner illustrated in Fig. 34. In making these drawings the draughtsman will find that the work can be more easily and quickly done by drawing them on the dull side of tracing-cloth or paper laid over the finished elevations. The sills, posts, girts and plates should be drawn first, then the studding which frames the door and window-openings, next the braces and lastly the filling-in studs. The latter are often indicated by a series of single lines.

The sizes of all special timbers and the centers of all openings should be carefully marked on the drawings. The sizes and heights of the window-openings are best designated by giving the sizes of the lights of glass and the heights above the floor of the finished stools as shown in Fig. 34. The heights, also, of the plates and girts and the pitches of the roofs in terms of rise to run, should be correctly given.

In locating a brace it should be remembered that it is most effective when at an angle of 45 degrees, and that it should be connected with the post at a height above the floor varying from one-third to one-half the height of the story. Every dimension necessary for the complete construction of the frame should be found on the framing-drawings.

No drawings made by the architect require greater thought and exactness than the framing-plans, for upon them depends the proper construction of the building and often also, its safety; and, moreover, any error in the figures generally leads to considerable expense through waste of material and labor, for which expense the architect is in most cases responsible.

4. FLOOR-CONSTRUCTION.*

88. FLOORS OF WOODEN BUILDINGS. The floors of wooden buildings are usually constructed of 2-inch planks called

* See, also, Art. 448, Chap. VII.

"joists" or "floor-beams," which are set on edge and spaced either 12 or 16 inches apart on centers. The outer ends of these joists are supported, in the first story, by the sills and the inner ends by wooden girders or brick walls, the girders or walls being generally placed directly under the "bearing partitions" of the first story.

The outer ends of the second-story joists are supported by the girts, as shown in Figs. 31 and 35, and the inner ends by the interior partitions.

The outer ends of the attic-floor joists may rest either directly on the wall-plates, as shown in Fig. 31, or on false girts, as shown in Fig. 35, depending upon the design of the framing. The inner ends of the attic-floor joists are supported by the second-story partitions. In a one-and-a-half-story house the attic joists are supported at their outer ends by being spiked to the sides of the rafters.

1. *Sizing and Crowning Floor-Joists.* The first step toward framing the floors is the sizing and crowning of the floor-joists. For spans of 16 feet or over all floor-joists should be "crowned," that is, the top should be dressed to the arc of a circle, with a rise of ¼ of an inch in the center for every 16 feet of span. This must be done by hand with a hatchet and plane. The ends of the joists are "sized" by machinery so that the distance from the bearing to the top of the joists will be the same in each, thus insuring an even surface on top. Ordinary timbers often vary from ¼ to ½ of an inch in width, and if they are not sized at the ends, when they are set in place, their upper surfaces will not be in the same plane. The object of the crowning of joists is to offset their inevitable deflection or sagging and to thus secure a level floor.

In the Eastern States the under side of the floor-joists is almost always cross-furred with 1½-inch strips, so that any irregularity in the depth of the joists is easily neutralized. In many of the Western States, however, this is very seldom, if ever, done, and all the joists, if not already in that condition, have to be dressed to a uniform width. A little irregularity in a ceiling can be made to disappear in the plastering.

2. *Spacing of Floor-Joists.* This should not exceed 16 inches, measured from center to center, and where the ceilings are not furred, it is better to space them 12 inches on centers. (See, also, Arts. 20, 22, 94 and 102.)

89. DETAILS OF FLOOR-FRAMING. 1. *Framing of Joists to Sills.* The connection of the floor-joists to the sills should be such that the sills will support the joists without weakening either more than absolutely necessary; then if the foundation-walls settle, the joists will not move unless the sills move also. The ideal connection of joists to sills is made by hanging the joists in "Goetz" or

"Duplex" hangers, as shown in Fig. 42. In this construction the full strength of each joist and sill is retained, each joist being secured to the sill and also suspended from it.

The next best method, and the one more generally employed, is

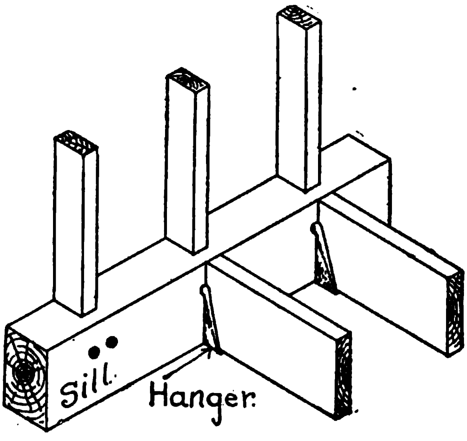


Fig. 42. Ideal Method of Framing Joists to Sills.

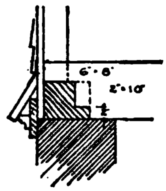


Fig. 43. Common Method of Framing Joists to Sills.

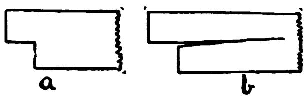


Fig. 44. Cutting Ends of Joists in Cheap Construction.

shown in Fig. 43. In cheap buildings, where only 4 by 6-inch sills are used, the floor-joists are often cut as at *a*, Fig. 44, and the sills are not mortised. This is very poor construction, as it greatly weakens the joists, so that comparatively light loads produce cracks, as shown at *b*. A floor-joist cut as at *a*, Fig. 44, and supported as at *a*, Fig. 45, will carry less than half the load it would if reversed and supported as at *b*.

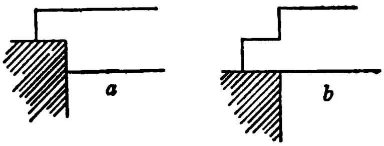


Fig. 45. Cutting Ends of Floor-Joists.

The outer ends of the second-story joists are merely sized to a uniform depth and spiked to the top of the girt, if a solid girt is used. Where a false girt is used each joist should have a notch, about ¾ of an inch deep, cut in the bottom to fit over the top of the girt, as shown in Fig. 31. Wherever practicable the joists should be placed so as to come against the sides of the studs and the two should be spiked together. The outer ends of the attic joists, if they rest on the plates, are merely spiked to them; if they rest on false girts they are notched the same as shown for the second-story joists and spiked to the studs.

2. *Framing of Joists to Girders.* The framing of the joists flush with the girders is advisable in order to give sufficient head-room in the basement. When the joists are placed directly on top of the gird-

ers, the latter interfere with the heating and piping-systems and often necessitate placing the furnace in a pit in order to obtain the required head-room. If the joists are framed flush into the girders, as shown in Figs. 46 or 81, the shrinkage is much less than if they rest on them.

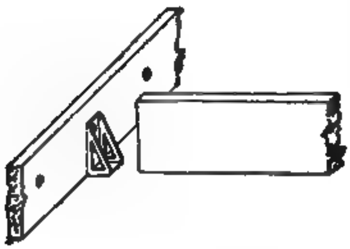


Fig. 46. Joist Framed Flush with Girder.

The old methods of framing joists into girders, as illustrated in Figs. 47 and 48 are used much less than formerly, and the framing by nailing and bolting strips to the girders, as shown in Fig. 49, should be used only for light and cheap work. By these methods of construction the joists are weakened and tend to split when loaded. If mortise-and-tenon joists are used, as shown in Figs. 47 and 48, girders must have sufficient additional size to offset the weakening effect of the

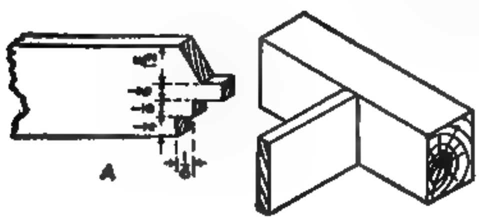


Fig. 47. Old Method of Framing Joist into Girder.

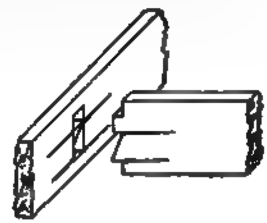


Fig. 48. Old Method of Framing Joist into Girder.

mortise-holes. The mortise-holes coming below the neutral axis decrease the strength of the girder. Hangers of the "Duplex" type are attached to the girder at, or above, the neutral axis, and there-

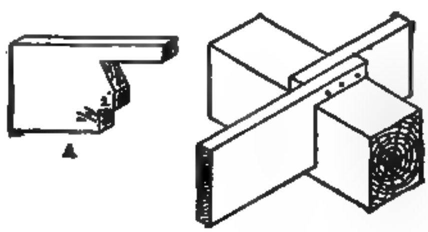


Fig. 49. Common Method of Framing Joist to Girder.

Fig. 50. Girder Dropped in Joist-Framing.

fore do not affect the tension-fibre strength of the girder; and, in addition, there is only one-half the amount of shrinkage resulting

from the use of steel hangers. Fig. 50 shows the girder dropped several inches. This construction is not economical and costs more than that in which joist-hangers are used. Usually these small-

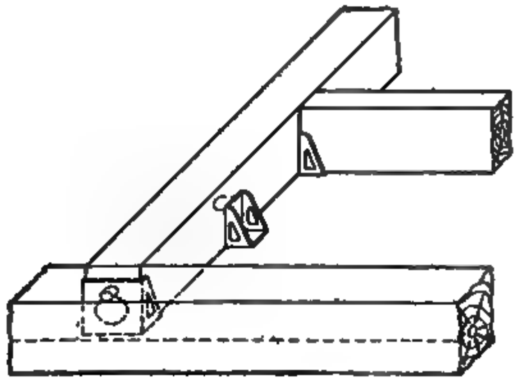


Fig. 51. Framing Around Opening in Floor.

sized hangers are carried in stock by hardware-dealers and can be used at a slight additional expense.

90. FRAMING AROUND STAIR-WELLS, CHIMNEYS, etc.

Fig. 52. Best Method of Framing Around Chimney-Breast.

This should be done as shown in Fig. 51, or by using hangers of the "Duplex" type, or with steel hangers. The National Board of Fire Underwriters requires that the ends of beams which are framed

around chimneys and are in proximity to flues, shall be protected to prevent charring. Fig. 52 shows the best method of framing around chimneys, etc.

For heavy framing, all headers and tail-beams should be hung in hangers as described for brick buildings, Arts. 95, etc.

91. PORCH-FLOORS. This construction should be framed with the joists parallel with the walls of the house, so that the floor-

Fig. 53. Framing of a Porch Floor.

boards will be at right-angles to these walls and pitch outward 1 inch in from 6 to 8 feet. It is also customary to drop the porch-floor about 6 inches below the first-story floor of the building. Fig. 53, from an article in the "Inland Architect" on isometric drawing, by Charles E. Illsley, architect, gives a clear representation of the proper framing of a porch-floor, although brick piers are more durable than the wooden posts shown in the figure. If the porch is over 6 feet wide or the supports are farther apart, the size of the cross-timbers should be increased accordingly.

Fig. 54. Floor-Joist Bridging.

92. BRIDGING. After the floor-joists are leveled and secured in place and before the floor-boards are laid, they should be bridged at the middle of the span for spans from 8 and 16 feet, and with two rows of bridging for spans from 18 to 24 feet, as shown in Fig. 54. For dwelling-house floors, 1 by 3-inch bridging is sufficient. For 14 inch joists, 2 by 3-inch stuff should be used. The pieces should be cut on a miter to the exact length and each end of each piece nailed with two tenpenny nails. Both ends of each piece of bridging should be nailed

at the same time and before the joists are loaded in any way and the bridging should be continuous and in straight lines across the room.

It must not be understood that bridging increases the strength of a floor so that it will carry a greater distributed load than it will support without bridging, for such is not the case, except in so far as it prevents the joists from twisting or buckling sidewise. The principal advantage derived from the use of bridging is in the case of concentrated loads, such as the legs of heavy pieces of furniture, and also in the case of suddenly applied loads, such as jumping, the moving of heavy articles, etc. In such cases the joist immediately beneath the weight is materially assisted through the bridging by the

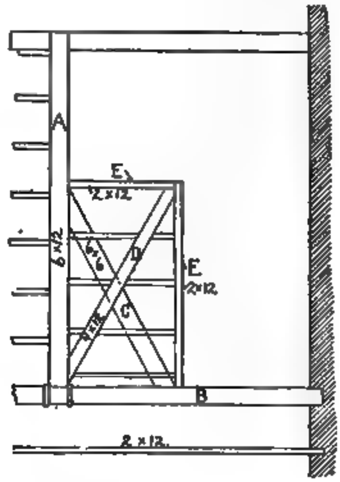


Fig. 55. Framing a Projecting Corner. Plan.

Fig. 56. Detail of Framing for a Projecting Corner.

joists on each side of it. Mr. R. G. Hatfield found by testing a model floor, constructed one-eighth full size, that it required three times the load to produce the same deflection in a bridged beam that it did in one not bridged.

93. FRAMING A PROJECTING CORNER. It often happens, in dwellings and tenement-houses, that the stairs are built as shown in the plan, Fig. 55, and it is desirable to extend the upper floor into the stair-well without any vertical support at the corner *A*. If there is a partition or girder under the dotted lines *B* and the floor-joists run at right-angles to it, the projecting portion can be easily supported by merely extending the floor-joists the desired distance beyond the supporting partition.

Very often, however, the joists run the other way and there is no support below, so that the corner must be made self-supporting; and

just how to make it so is sometimes a puzzle to the young architect or draughtsman. Probably the best method of doing it is that shown by the partial framing-plan (Fig. 56).

The trimmer *B* and header *A* are first framed in the usual way; then a heavy timber (*C*), of about half the depth of the floor-joists, is framed diagonally between *A* and *B*, with its under side flush with the joists. This forms a support, at its center, for the cantilever *D*, which in turn supports the outer end of the pieces, *E, E*. The piece *D* should be made the full depth of the joists and notched over the piece *C*. Short pieces of joists are cut in between the timbers *A, D* and *E*, and the framing is then ready for the flooring and lathing.

There are many places where this method of framing may be employed, particularly in tower-stairways. The same method could be carried out with iron framing, omitting the short pieces of joists. If the projection is very great, however, and the floor is a heavy one, it is better to support the corner directly, either by a post or rod.

94. LAYING OUT THE FLOOR-FRAMING PLANS. The framing of floors may be most conveniently drawn on tracing-cloth or thin bond-paper laid over the corresponding floor-plan. The framing-plan should show the interior supports or partitions in the story below and the framing around all openings, chimneys, etc. Provision should be made, also, for the support of all partitions that do not come over partitions below (see Arts. 107 and 108) and for nailing the ends of the floor-boards where they come against walls or partitions. Any necessary framing for hot-air pipes and floor-registers and the position of the same should be shown and the location of the bridging indicated.

The size and position of all special timbers, including the joists that support partitions, all headers and trimmers and the size and position of all openings should be accurately figured. In short, the framing-plans should afford all information necessary for erecting the frame of the building without consulting the other plans.

If there is any special construction or peculiarity of framing required it should be indicated on the margin by three-quarter or inch-scale details.

Fig. 57 shows the framing of a part of the second floor and the supports in the story below for a wooden dwelling laid out in the above manner. For large buildings the framing-plans may be drawn to a scale of 1/8 of an inch to the foot and the common joists indicated by single lines. All special timbers should be colored yellow on the drawings to make them more prominent.*

95. FLOORS OF BRICK BUILDINGS. The framing of the

* See, also, Kidder's "Architects' and Builders' Pocket-Book," "Layout of Floor-Framing," Chap. XXI.

floors in brick buildings is essentially the same as in wooden buildings, the only difference being in the connections of the floor-timbers with the outer walls.

In brick buildings the outer ends of the joists are naturally supported by the brickwork. Hanging the timbers in wall-hangers is considered the best construction, as dry-rot is prevented and the

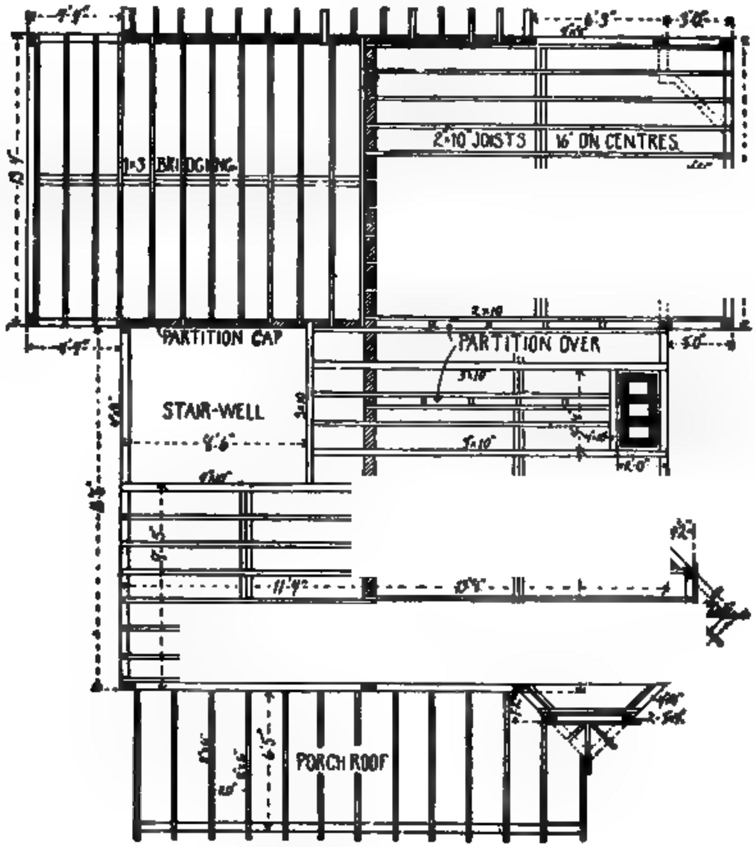


Fig. 57. Second-Floor Framing-Plan for a Dwelling.

construction is approved by the insurance-underwriters. A cheap method sometimes employed, however, consists in building the timbers directly into the wall, each timber having a bearing of about 4 inches on the wall and being anchored securely every few feet by iron anchors. For residences and in very light construction this method may not be seriously objectionable; but in heavier work it should not be employed. In the latter case wall-hangers, wall-boxes

or wall-plates should be used. Another difference in the methods of framing brick and wooden buildings is in the manner of supporting the joists over the outside door-openings and window-openings. In

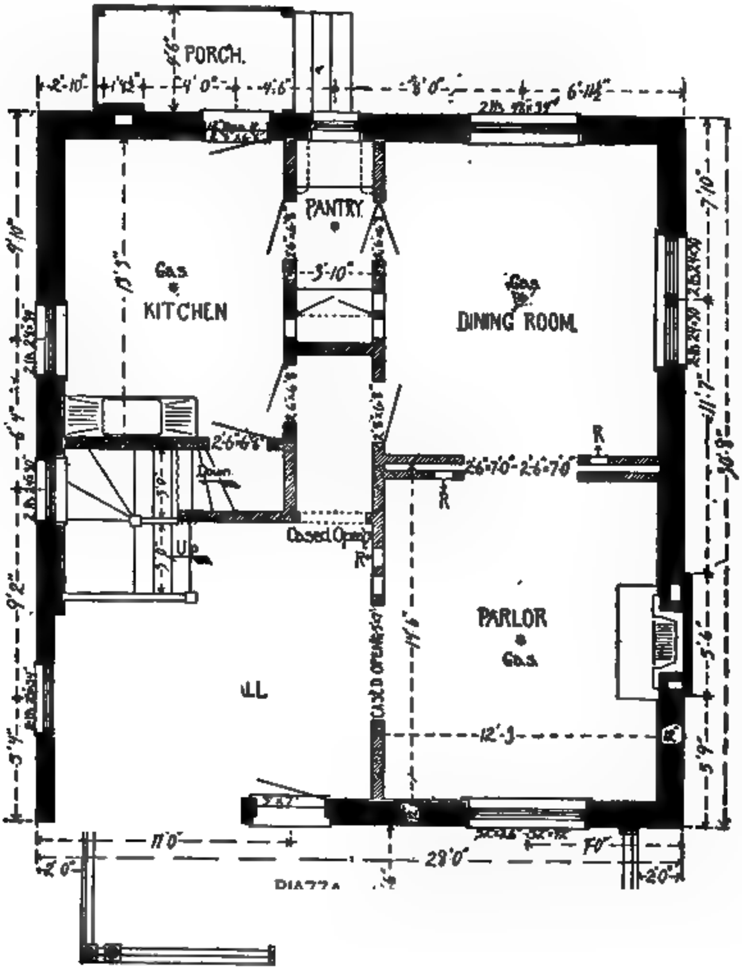


Fig. 58. First-Floor Plan. Small Brick Dwelling.

wooden buildings the joists are supported by the sills, girts or plates, while in brick buildings there is nothing corresponding to these. When the top of a window-opening or door-opening is 2 feet or more below the bottom of the joists there is sufficient room

to turn a brick arch over the opening to support the joists; but when the top of the rough opening comes within 14 inches of the joists, as is usually the case with basement windows, the joists

Fig. 59. Floor-Framing for Plan Shown in Fig. 58.

should either be framed into a header, as shown in Fig. 59, or a steel beam should be placed over the opening. This is a detail that must not be overlooked in laying out the framing-plans. Another

point of difference is that in brick buildings a floor-joist must always be placed against a wall that is parallel with the joists, to afford a nailing for the ends of the floor-boards, laths or furring-strips. In cheap wooden buildings the underflooring is sometimes nailed to the girt and the single parallel joist omitted; but this is not good practice, as it affords no nailing-space for the over-flooring or finished flooring. In all other respects the laying out of the framing is the same as described for wooden buildings. Fig. 59 is the framing-plan of the first floor of the small brick building shown in Fig. 58, which includes all the features usually met with in small brick dwellings and tenement-houses. In this case it was necessary to drop the girder 6 inches below the top of joists to leave room for the boots on the hot-air pipes. This is a point that should not be overlooked when laying out the framing of buildings that are to be heated by hot air.

For buildings other than dwellings, heavier framing than that which has been described is often required; and although the principles involved are the same, the details are often somewhat different. Many of these details are as applicable to wooden as to brick buildings; but as they do not as frequently occur in wooden buildings it seemed best to describe them here.

96. BEAM AND GIRDER WALL-SUPPORTS AND ANCHORS. When the timbers are built into the brickwork in ordinary construction, their ends should be beveled as shown in Fig. 60

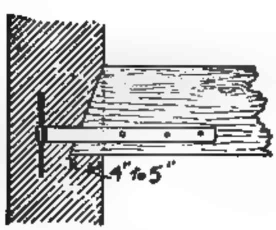


Fig. 60. Common Method of Building Joists into Brick Walls.

Fig. 61. Effect on Wall of Falling Joist Anchored at Top.

and should bear on the wall not less than 4 or 5 inches. In order to cheapen the cost of construction the timbers are often left "square"; but this is objectionable, as in case of fire, in falling down they lift the bricks and throw the wall over. The joists are usually anchored every 4 or 5 feet to tie the building and to prevent the joists and wall from pulling away from each other. The anchors extend to within

4 inches of the outside face of the wall and are spiked near the bottom of the joists to lessen the tendency to pull the wall over in case the joists fall because of a fire. Fig. 61 shows the effect on the wall of a falling joist anchored at the top. Such anchors, wherever placed, are apt to pull down the wall with a falling joist.

During the past few years the use of wall-hangers, as shown in Figs. 72 and 74, has become very general. The advantages of wall-hangers are that they reduce dry rot to a minimum, and also, in case of fire, that they are self-releasing, thus leaving the wall perfectly

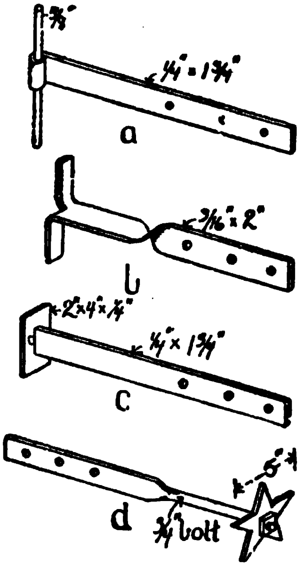


Fig. 62. Types of Wall-Anchors.

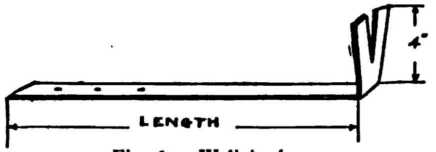


Fig. 63. Wall-Anchor.

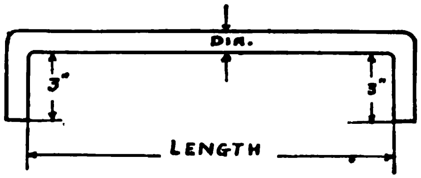


Fig. 64. Dog-Anchor for Wooden Girders.

Fig. 65. Strap-Anchor for Tying Wooden Girders.

intact. Shorter joists can be used, as they are carried entirely clear of the walls. This reduces the cost of the timber and the saving in many cases is equivalent to the cost of the hangers. When wall-hangers are used there is no hole in the masonry, the hangers being built directly into the brickwork and every fourth or fifth hanger anchored.

In Fig. 62, *a* shows the "T wall-anchor" which is commonly used to secure joists to a wall. The application is shown in Fig. 60. In Fig. 62, *b* shows the "split wall-anchor," which serves the same purpose as the T wall-anchor. In both cases they are spiked to the timbers. Frequently an anchor like that shown in Fig. 63 is used, and if it is turned up to catch two bricks it is as good as any. For anchoring wooden girders across the building, the "dog-anchor," Fig. 64, is used. When the girders butt against one another, the

ends of the dog-anchors are sometimes tapered so that they can be driven into the timbers. "Strap-anchors" similar to that shown in Fig. 65, tie the building in the direction of the girders and are merely spiked to the sides of the timbers. This form of anchor is in more common use than the dog-anchor. When the girders butt against the posts and no provision for anchoring is made on the post-caps, strap-anchors are used.

Fig. 66 shows a common anchor for fastening a sill or wall-plate. This is also called a "plate-bolt."

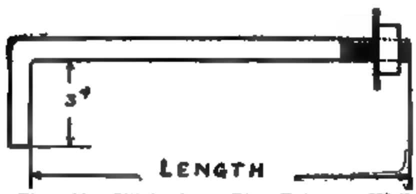


Fig. 66. Sill-Anchor, Plate-Bolt or Wall-Plate Anchor.

Fig. 67. Common Tie for Brick-Veneer Wall.

For veneer-work the brick veneer must be fastened to the uprights and a common type of veneer-tie is shown in Fig. 67.

The various building codes, in specifying anchors, usually read as follows:

"Each tier of beams shall be anchored to the side, front, rear or party walls at intervals of not more than 8 feet, with strong, wrought-iron anchors. The ends of beams resting upon girders shall be butted together end to end, strapped with wrought-iron straps of the same size, placed the same distance apart as required for the wall-anchors and placed on the same beams that have wall-anchors. Or they may lap on each other at least 12 inches and be well spiked or bolted together where lapped, or be spiked to their bearings and to the studs, as in balloon framing. Where beams are supported by girders, the girders shall be anchored to the walls and fastened to each other by suitable straps."

"Every pier or wall, front or rear, shall be well anchored to the beams with the same-sized anchors as are required for the side walls. These anchors shall hook over the second joists, but no anchor shall cut into a beam or joist within a distance of 4 feet of its center."

"When joists or beams are hung in standard joist-hangers or wall-hangers, their wall-ends shall be anchored and their girder-ends strapped together as above specified."

If the wall is at the side or rear of a building, where appearance is not of much consequence, it is better to have the anchor pass entirely through the wall and to have a plate on the outside. An anchor

fastened in this way holds much better than when it extends only to the middle of the wall. The cheapest form of anchor for this purpose is the one shown at *c*, Fig. 62. It has a thin plate of iron doweled and upset on the outer end. This type of anchor, also, may extend only to the middle of the wall.

For anchoring the ends of girders, or where a particularly strong anchor is desired, the form shown at *d*, Fig. 62, is undoubtedly the best. This anchor is made from a ¾-inch bolt, flattened out for spiking to the joists and provided with a cast-iron star washer. It possesses the advantage of having on the outer end a nut, which, if necessary, can be tightened after the wall is built. For anchoring walls that are parallel to the joists the anchor must be spiked to the top of the joists, and should either be long enough to reach over two joists or a piece of 1¼-inch board should be let into the top of three or four joists and the anchor spiked to it. After the floor-joists are set in place and the anchors spiked to them, the brick-masons fill in between the ends of the joists and around the anchors with brickwork.

97. PREVENTION OF DRY ROT. While the method of building the joists directly into the brick walls and anchoring them as above described gives ample strength for ordinary floor-construc-

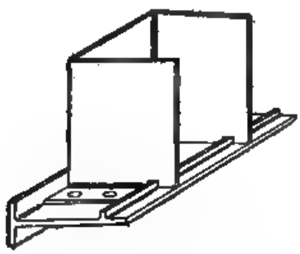


Fig. 68. Duplex Wall-Box.

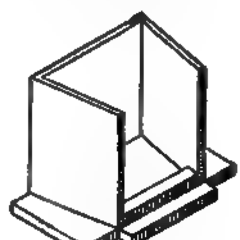


Fig. 69. Goetz Wall-Boxes.

tion, it has two serious objections. No ventilation is provided around the ends of the joists and the wall is apt to be destroyed in case of fire. The lack of ventilation is liable to cause dry rot in the wood, especially if it is not well seasoned. Theoretically, therefore, an air-space should be left around the ends of the joists; but it is rather difficult to provide for this, especially if the wall is not furred. A practical method for securing ventilation around the ends of the joists is the one involving the use of wall-boxes similar to those shown in Figs. 68, 69 (69 showing the original forms of the "Goetz" box-anchor) and 809. These wall-boxes hold the joists in position and at the same time afford an air-space around the ends of the latter as shown in Fig. 70. (See, also, Art. 32.)

98. BEAM-RELEASING ANCHORS. The second objection, also, mentioned above, may be overcome by using these boxes. They have ribs or lugs cast on the bottom, as shown in the figure, and corresponding notches are cut in the bottom of the joists, so that when the latter are in place they are securely fastened to the boxes, which being dovetailed into the walls, afford sufficient anchorage to tie the building. The "Duplex" wall-box, Fig. 68, has, in addition, a vertical rib cast on the back of the bottom plate which acts as an anchor in the brickwork. Large beams or girders may be further secured by anchoring each box to the wall by a bolt passing through a hole in the back, as shown in Fig. 70. If a joist falls, in case of fire, it releases itself from the box without pulling the wall over. Covers are used for the large wall-boxes; but for small timbers the brickwork usually spans the box and a cover is not required. The boxes shown are made of cast iron, except the one in Fig. 68, which is made with a malleable-iron bottom plate and a steel box.

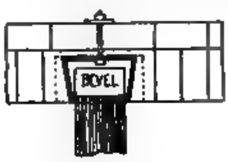


Fig. 70. Wall-Box with Air-Space.

Wall-plates, shown in Fig. 71, are sometimes used instead of wall-boxes. They reduce the pressure on the wall and also provide an anchorage, but do not prevent dry rot. The wall-plate, however, complies with the building codes in many cities.

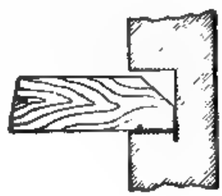


Fig. 71. Duplex Wall-Plate.

Another device which allows joists to fall without injury to walls is the wall-hanger, one type of which, the "Duplex," is shown in Fig. 72. By the use of wall-hangers the joists are hung from the walls instead of being built into them. The bracket shown on the back of the hanger is built into the wall and a lug on the bottom holds the joist; every fourth or fifth hanger is also bolted to the wall. One advantage possessed by these hangers is that they do not weaken walls at the floor-levels. In case the joists fall there is no danger of the walls falling also, as shown in Fig. 73. There is, moreover, no danger of dry rot.

Fig. 72 Duplex Wall-Hanger.

Wall-hangers are especially desirable for party walls and partition-walls, as joists greatly weaken them where they enter from both sides. When joists are hung in hangers a wall is as strong

at the floor-level as elsewhere. (See Fig. 74.) Wall-boxes or wall-hangers are used in large brick buildings and particularly in mercantile buildings. The "Duplex" wall-hanger, Fig. 75, for efficient heavy construction, is made of one piece of steel and bears

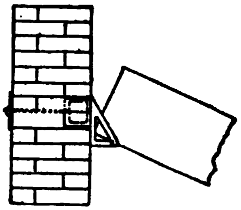


Fig. 73. Release of Joist Without Damage to Wall.

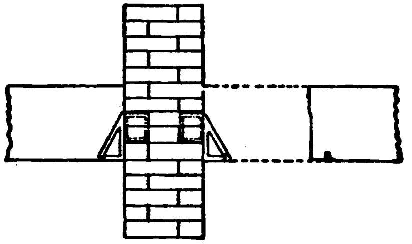


Fig. 74. Wall-Hangers Applied to a Party Wall.

the label of approval of the National Board of Fire Underwriters. Stirrup types of wall-hangers should not be used for this kind of work.

The importance of anchoring the floors to the walls, and thus preventing the latter from being thrown outward, either from settlement in the foundation or from pressure exerted against the inside of the walls, cannot be over-estimated and these details should never be overlooked. When the first tier of joists is not more than 3 feet above the ground it is not necessary to tie them to the walls, except in storage-buildings, or where the first story is over 15 feet high; but all other floors and all flat roofs should be securely anchored to all outside walls, to the side walls as well as to the end walls, at least once in every 6 feet. In some localities the outer ends of the floor-joists are supported on ledges corbelled out on the inside of the walls.*

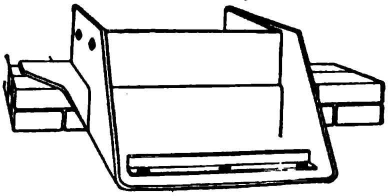


Fig. 75. Wall-Hanger for Heavy Construction.

99. WOODEN WALL-PLATES. Brick buildings with pitched roofs require wooden wall-plates to receive the ends of the rafters; the plates also greatly stiffen the walls to resist the thrust of the rafters. They should be made of two thicknesses of planks, 8 inches wide for an 8 or 9-inch wall and 12 inches wide for thicker walls, and should be bolted to the top of the walls by ¾ or ⅞-inch bolts at least 2 feet long, imbedded in the brickwork. On the lower end of each bolt a large wrought-iron washer should be

* For a description of this method of support, see Fig. 204, page 358, in "Building Construction and Superintendence, Part I, Masons' Work." F. E. Kidder.

placed to hold the bolt in the wall. The planks should break joint, and where possible the plates should form an unbroken tie around the building. Before bolting the plates in position they should be bedded in mortar. For small dwellings a single plank is sufficient, but it should extend from angle to angle. The rafters are spiked to the plates, as in wooden buildings, and often the attic-floor joists rest on the plates and are spiked to them. (See Figs. 128 and 133.) When the plates are above the attic-floor, diagonal ties or braces should be spiked to the rafters and to the floor-joists, as in Fig. 128,

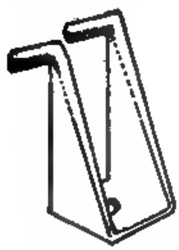


Fig. 76. Hangers for Dwellings and Light Construction.

to prevent the roof from spreading the walls. The rafters of flat roofs are built into the walls in the same way that the floor-joists are built in and the walls are carried 12 or 18 inches above the roof.

100. FRAMING OF HEADERS AND TRIMMERS. The ordinary method of framing around openings and stair-wells has been discussed in Art. 90. In most large cities, however, the building codes now require that headers over 4 feet long, in all buildings except dwellings, shall be hung in hangers or stirrups. In some cities this applies to residences, but a longer length of header is allowed. In heavy construction the saving over the old method in the extra amount of lumber required offsets the cost of the hangers. The full strength of the header at the end is obtained, and in case of fire such a joint would stand much longer than the mortise-and-tenon joint. For dwellings and light construction the author recommends the use of the "Duplex" type shown in Fig 76 or the form of steel hanger shown in Fig. 81.

1. *Hangers.* These hangers are made in great variety to suit any size of timber and are now carried in stock in most of the larger cities. They are supported, in the "Duplex" type, by inserting the lugs into holes bored near the center of the trimmer. This gives them an advantage over stirrup hangers because they are affected by only about one-half the shrinkage in the trimmer; while the ordinary stirrup iron is supported at the top of the timber,

and consequently the bottom of the stirrup must settle, and the header with it, by the amount of shrinkage in the trimmer. Unless the trimmer is well seasoned this dropping of the header, due to the shrinkage of the trimmer, will be sufficient to crack and distort plastered ceilings. This shrinkage is often sufficient to cause unevenness in the floor, as shown in Fig. 77. Even where

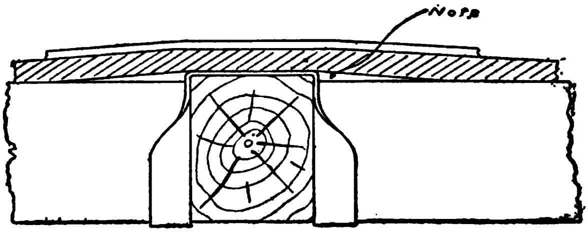


Fig. 77. Effect on Floor of Shrinkage Near Hanger.

joist-hangers are used, pains should be taken to secure well-seasoned timber.

With the "Goetz" hangers, the beam supported is tied to the hanger by a spike driven into the beam through a hole in the bottom of the hanger. For large timbers, lag-screws may be used. The "Duplex" hangers in the smaller sizes hold the joists by means of lugs on the sides, as shown in the cut at *A*, Fig 76. The larger hangers have a bolt or lag-screw, which passes through the end of

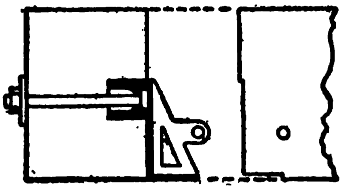


Fig. 78. Duplex Hanger Bolted to Trimmer.

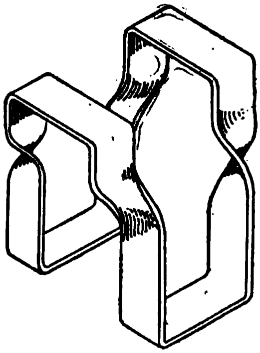


Fig. 79. Stirrup Iron.

the joist and ties the joist to the hanger. This hanger may also be bolted to the trimmer, as shown in Fig. 78, thus absolutely preventing the trimmer from spreading. The tail-beams, also, should be hung in hangers when the headers are very long, as shown in Fig. 52.

2, *Stirrup Irons.* Stirrup hangers or stirrup irons were the

first to replace the old-style mortise-and-tenon framing and are shown in Figs. 79, 80 and 81. The stirrup type of hanger, however, is objectionable as all the load is brought on the edge of the timber, causing the hanger to crush into it, as shown in Fig. 815 of the Appendix, "Points that Should be Considered, etc." While steel is amply strong for the tension, it is subjected to bending in stirrup hangers, and must, therefore, be of sufficient extra thickness and size to overcome this bending. The dropping of the header due to shrinkage is also objectionable in hangers of this type. They are not generally carried in stock, but can be easily made by any blacksmith.

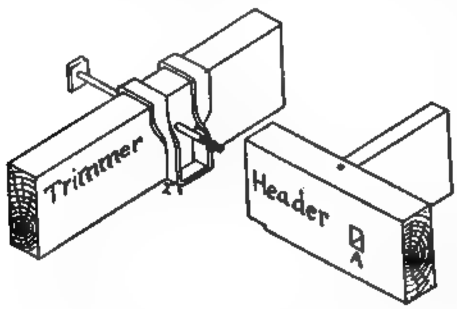


Fig. 80. Stirrup Iron Applied to Header and Trimmer.

The use of the "Duplex" type of hangers for heavy timbers is now general in warehouse-construction, as they allow for the full strength of the timber and a minimum amount of shrinkage. The tests and actual experience have shown that when the holes for this type of hanger are bored at, or above, the neutral axis, the strength of the girder is not materially affected.

Stirrup hangers should be made from 3/8 to 5/8 of an inch thick and from 2 to 4 inches wide, according to the size and length of the timbers they support. They may be made double, as shown in Fig. 79, or single, as shown in Fig. 81. When single, the end of the hanger should run down at least 1½ inches over the further side of the trimmer, as shown in Fig. 83. As stirrup irons are ordinarily used, the end of the header is simply spiked to the trimmer to keep the latter from spreading until the floor is laid, the latter being depended upon finally to prevent the trimmers from spreading and consequently the headers from dropping.

Fig. 81. Application of Stirrup Irons.

A better procedure, much followed in Boston, is to tie the end of the header to the trimmer by a 3/4 or 7/8-inch "joint-bolt," which is an ordinary square-headed bolt about 18 inches long. A hole

slightly larger than the bolt is bored through the trimmer and into the end of the header. A square hole is then cut into the side of the header as at *A*, Fig. 80, just large enough to slip in the nut, which is pushed in opposite the bolt-hole. The bolt is then pushed in, the screw end started in the nut and the bolt screwed up by turning the head. This draws the two timbers tightly together and brings a perfectly dead weight on the hanger.

The following table shows the size of iron bars recommended for stirrups and also the safe strength of the stirrups:

TABLE III.

Sizes of Iron Bars for and Safe Strength of Stirrups.

Sizes of iron bars.	Sizes of joists supported.	Safe strength of stirrups.
¼ x 2 inches	2 x 8 to 3 x 10 inches	10,000 pounds.
⅜ x 2 ½ "	4 x 10 to 4 x 12 "	18,000 "
⅜ x 3 "	6 x 12 to 3 x 14 "	22,000 "
½ x 3 ½ "	8 x 12 to 4 x 14 "	30,000 "
½ x 4 "	6 x 14 "	36,000 "
⅝ x 3 ½ "	8 x 14 "	40,000 "
¾ x 4 "	10 x 14 "	45,000 "

Figs. 82, 84, 85, 86 and 87 represent various other types of steel hangers. They are to be spiked to the timbers and are amply strong for ordinary construction, but would be improved by hooking over

Fig. 82. Van Dorn Hanger.

Fig. 83. Duvinage Stirrup Hanger.

the beams, as shown in Fig. 81. See Appendix for article on "Points that should be Considered in Selecting or Designing Joist and Wall-Hangers."

101. FLITCH-PLATE GIRDERS.* It sometimes occurs that the spans and loads are too great to permit the use of ordinary timbers. In this case a flitch-plate girder is often used, consisting of a steel plate between two wooden beams, securely bolted together by ¾-inch bolts which are spaced from 18 to 24 inches on centers

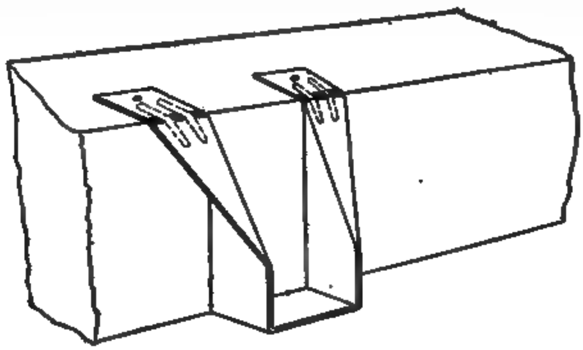


Fig. 84. "Ideal" Steel Hanger, Attached to Timber.

and staggered. It has been found in practice that the plate should be about one-sixteenth of the total thickness of the girder, or in other words the thickness of the wood should be fifteen times the thickness of the plate. The bolts should be placed not less than 2 inches from the edges of the timbers and there should be two

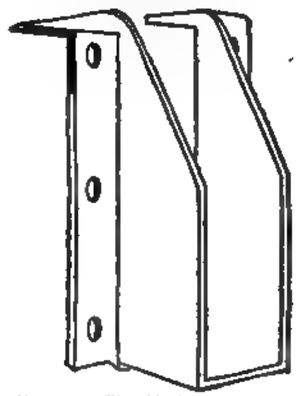


Fig. 85. The "Ideal" Steel Hanger.

Fig. 86. The National Hanger

bolts placed over each other at the ends of the girder. The depth of the plate should be ½ an inch less than that of the timbers, to

* See, also, "The Architects' and Builders' Pocket-Book." F. E. Kidder. Chap. XVII, "Strength of Built-up Wooden Beams, Flitch-Plates and Trussed Girders," for methods of calculating safe loads for these girders.

allow for shrinkage. In framing joists to flitch-plate girders it is an advantage to use hangers of the type shown in Fig. 88, as the bolts can be run through the hangers themselves, thus bolting the girder and hangers and also tying the construction. The nip-

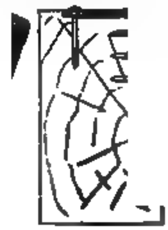


Fig. 87. The Lane Hanger.

ples on the "Duplex" hangers are countersunk so that the bolts will fit into them.

A metal girder is less fire-resisting than a flitch-plate girder, and it bends at a low temperature when exposed to fire. Since the

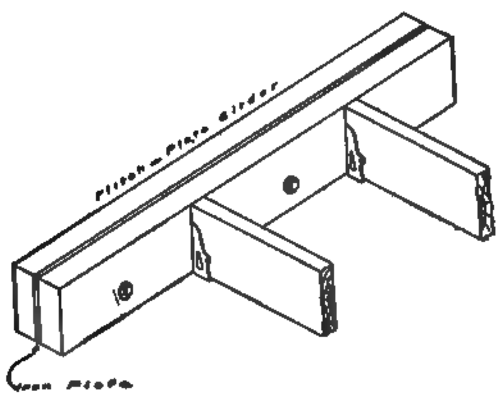


Fig. 88. Framing Joists to Flitch-Plate Girders.

flitch-plate girder has the plate incased in wood it protects the metal until the wood is destroyed.

102. WOODEN GIRDERS. In brick dwellings girders are generally used for supporting the first floor only and in the same way as described in Art. 89. In heavier buildings the load on the

girders, becomes so great that it is necessary to utilize the full section of the girder and very often steel beams are required. In mercantile buildings and warehouses girders are sometimes dropped below the beams, so as to avoid framing the latter into them.

1. *Heavy Wooden Girders.* When heavy wooden girders must be kept flush with the joists the latter should be supported by joist-hangers or stirrups. In lighter construction, where it is necessary

Fig. 89. Framing Joists to Heavy Built-up Wooden Girder.

to make girders deeper than the floor-joists, "bearing-strips" are frequently spiked and bolted to the bottom of the girders, as shown in Fig. 89. The depth of these pieces should be at least 4 inches for 10-inch joists, 5 inches for 12-inch joists and 6 inches for 14-inch joists. Three-quarter-inch bolts, spaced from 16 to 20 inches, may be used for 10-inch joists, and ⅞-inch bolts, spaced

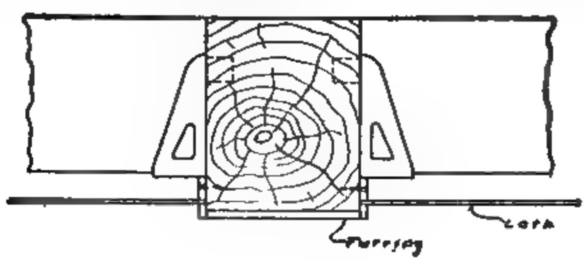


Fig. 90. Framing Joists to Heavy Wooden Girder.

20 and 16 inches respectively, for 12 and 14-inch joists. The bolts should be placed a little above the center of the bearing-strips, and the ends of the joists should be spiked to the sides of the girders, as shown in the figure. For heavier construction, however, the joists should be hung in hangers or stirrups, as shown in Figs. 51 and 81. Figs. 89 and 90 show, also, the manner of strapping or furring the girders for lathing.

In designing the girders it should be remembered that deep girders are more economical than shallow ones; and that when framed flush, or nearly so, on top, they prevent the passage of fire through the floors.

2. *Built-up Wooden Girders.* In many localities it is impossible to obtain large timbers without making a special order for them from the mills, while planks of almost any size can be readily obtained, and generally at a less price per thousand feet. In such cases the girders may be built up of several planks placed side by side and bolted together, as in Fig. 89. The planks, however, should always break joints over supports. The bolts need not be larger than ⅝ of an inch in diameter and may be spaced 2 feet on centers, in staggered rows, two bolts being placed at each end of the girder. When each plank is the full length of the girder, the only use of the bolts is to keep the planks together and to distribute the load on all the planks.

The author believes that girders built up in this way are better than solid girders and that they are of equal if not of greater strength. They are not as apt to warp and there is less chance of using decayed timber. They are objected to, however, by the fire underwriters, as sparks are apt to lodge between the timbers, during a fire, sometimes causing a later breaking out of the flames. (See, also, Art. 101.)

103. STEEL-BEAM GIRDERS. When steel-beam girders are used, and it is necessary to keep the tops of the joists and girders flush, hangers or shelf-angles are used. In case shelf-angles are used, however, they must be riveted to the web of the I beam;

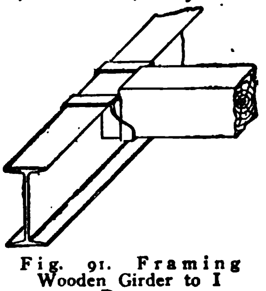


Fig. 91. Framing Wooden Girder to I Beam.

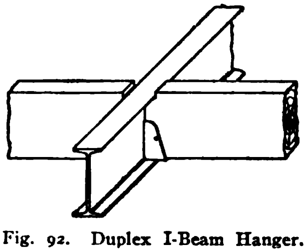


Fig. 92. Duplex I-Beam Hanger.

whereas when stirrups are used, as in Fig. 91, the same result is accomplished by simply catching them over the beam-flange. The steel stirrups can be made to carry the joists flush with the bottom of the I beams, or at any height desired. With the types of I-beam hangers shown in Figs. 92 and 93, the joists are framed flush with the bottom flanges of the I beams. When the joists are raised above

the lower flanges of the I beams, up to 3 inches, the hanger shown in Fig. 94 is used. This is called a "shelf-hanger" and has a shelf to raise the joists to the required height. Fig. 95 shows the type of hangers used when the joists are raised more than 3 inches above the lower flange of the I beam. The various "Duplex" I-beam hangers are so constructed that all the load is carried on the lower flange of the I beam, and this construction is universally approved. Particular care should be taken to frame the joists at least 5/8 of an inch above the top flange of the I beam and thus allow for the shrinkage.

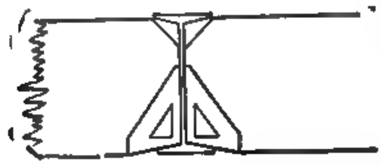


Fig. 93. Framing Joists to I Beam.

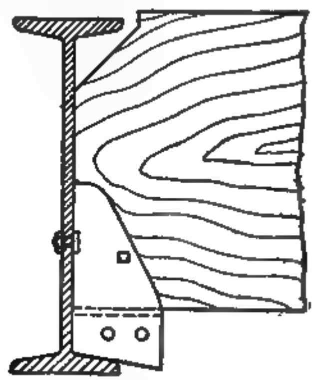


Fig. 94. I-Beam Shelf-Hanger.

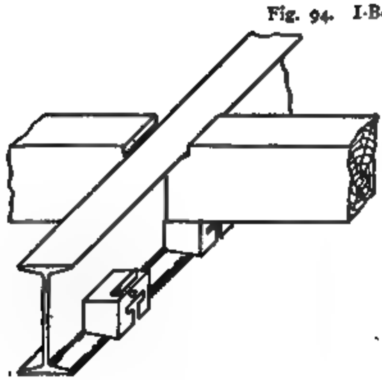


Fig. 95. I-Beam Box-Hanger.

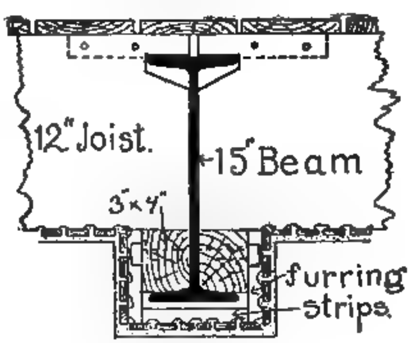


Fig. 96. Framing Joists to Deep I Beam.

For ordinary construction the method illustrated in Fig. 96 is frequently used. The framing and furring is easily arranged for lathing, or for casing. The floor-joists may be supported by bolt-

ing 3 by 4-inch hard-pine strips to the beam as shown. As the strips have a bearing on the lower flange of the beam, they need not be more than 4 inches deep, even for 14-inch joists. This is not considered the best construction, however, and a shelf-angle, riveted to the web, as illustrated in Fig. 97, is preferable to the bolting of a strip to the web.

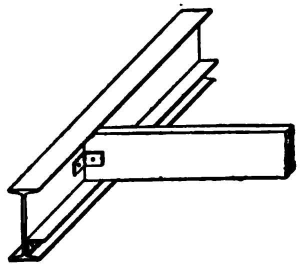


Fig. 97. Framing Joists to I Beam with Shelf-Angle.

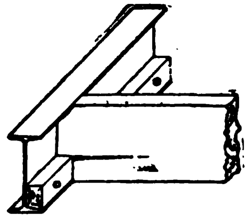


Fig. 98. Framing Joist to I Beam with Wooden Cleat.

Whichever of the last two methods of supporting the joists is employed, as above described, a sufficient number of bolts or rivets should be used to sustain the load carried by the strips or angles. Each ¾-inch bolt may be allowed to support 3,000 pounds on each side of the girder, and each ⅞-inch bolt, 4,000 pounds. Figs. 98 and 99 are open to objection on account of the weakening of the joists when loaded. The joists are sometimes placed directly on

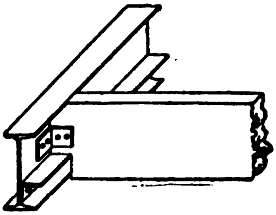


Fig. 99. Framing Joist to I Beam with Steel Angle.

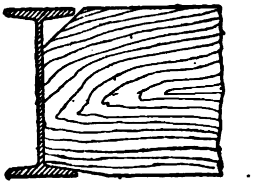


Fig. 100. Framing Joist to I Beam. Joist Resting on Lower Flange.

the lower flange, as in Fig. 100. In most cases, however, this does not give sufficient bearing for the joists unless the Bethlehem girder-beams are used. (See, also, Chap. VII, "Mill-Construction.")

104. STIFFENING A WEAK FLOOR. A floor that sags or springs considerably under moving loads may be made much stiffer by taking up a couple of floor-boards every 6 feet in the length of the floor and fitting slightly wedge-shaped blocks between the joists,

in a continuous line, as shown in Fig. 101. The blocks should be cut from 3-inch planks, the full depth of the floor-joists, and cut so that the grain of the wood will be at right-angles to the joists, and so that they may not become loose as the wood shrinks. Before putting the blocks in place, holes should be bored through the centers of the joists and a 1¼-inch rod passed through all of them, the rod having a head on one end and a nut on the other. After the rod is in, the blocks should be fitted closely in place and the nut then screwed up until the floor becomes crowned, owing to the shape of the blocks. A floor crowned in this way acts like a truss, and will be much *stiffer* under a moving load than when simply bridged in the ordinary way; although the *strength* of the floor, to support a distributed load, such as grain or large boxes of merchandise, is in no way increased. If the floor and ceiling must be kept perfectly level the upper surfaces of the joists will, of course, either have to be dressed off or the floor furred to a level; and the ceiling, also, will have to be furred.

Fig. 101. Method of Stiffening a Weak Floor.

105. FLOORS WITH INDEPENDENT CEILING-JOISTS. Floors have frequently been constructed with independent timbers for the floor and ceiling, the ceiling-joists being placed between the floor-joists, as shown in the cross-section, Fig. 102.

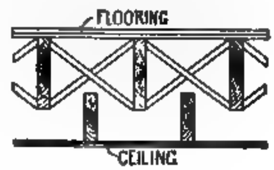


Fig. 102. Floor with Independent Ceiling-Joists.

The object of using two sets of joists is to prevent the passage of sound, and sometimes, as in dance-halls, to prevent the vibration of the floor being communicated to the ceiling. While this construction is undoubtedly the one best adapted (when wood must be used) to effect these results, it is very objectionable from the standpoint of fire-protection, as it affords free passage for flames in both directions and as the material is so disposed as to be rapidly consumed. It should, therefore, never be used in public buildings unless protected underneath by metal lath and plaster and above by some fire-proof material, such as "Salamander," laid between the floor-boards. This is not an economical construction, as it requires much more lumber to obtain the same degree of stiffness for both floor and ceiling, when divided into two tiers of joists, than it does when all the wood is in one tier.

It has been a common custom, also, in the construction of schoolhouse floors, in some sections of the country, to lay 2 by 4-inch scantlings on top of the floor-joists, and at right-angles to them, for the purpose of ventilating the rooms through the floors into the vent-shafts. Such construction should never, under any circumstances, be adopted, as it forms a veritable fire-trap in case a fire should be started in the room above.

5. PARTITION-CONSTRUCTION.

106. SIZES AND SPACING. The partitions in buildings of ordinary construction are usually built of 2 by 4-inch studding, spaced either 12 or 16 inches on centers, giving five or four nailings respectively, to the laths. For bearing-partitions, and also where the stories exceed 9 feet 6 inches in height, the spacing should not exceed 12 inches, as 16-inch spacing does not give sufficient stiffness for first-class buildings. For partitions exceeding 11 feet in height 5-inch or 6-inch studding should be used. A partition built of 2 by 5-inch studding, spaced 16 inches on centers, is much stiffer than one built of 2 by 4-inch studding 12 inches on centers, although the latter contains more lumber. A spacing of 16 inches, however, does not make as stiff a job of plastering, and for this reason a spacing of 12 inches is to be preferred in the better class of houses, no matter what the size of the studding may be. Five or 6-inch studding allows much more room for furnace-pipes and soil-pipes than the 4-inch studding.

107. SUPPORTS FOR PARTITIONS. In putting up the partitions it is important to build them so that there will be as little settling as possible from shrinkage. The *ordinary* method of building partitions, particularly in buildings not superintended by an architect, is that indicated in Fig. 103, which shows the studding of a first-story and the lower part of a second-story partition. From an inspection of this figure it will be seen that there are 37 inches of horizontal timber between the top of the basement piers and the bottom of the second-story studding; and, as ordinary spruce or white-pine timber will shrink across the grain about ½ inch per

Fig. 103. Faulty Method of Building Partitions.

foot, it would probably be found at the end of one or two years that the second-story partition had settled 1½ inches, and that the third-story or attic joists had settled with it. The endwise-shrinkage of timber is imperceptible. If the first and second-floor joists were supported at the outer ends, as shown in Fig. 35, there would be but 14 inches of horizontal timber between the foundation-wall and the second-floor joists, the sill being 6 inches and the girt 8 inches, which would only allow a shrinkage of about ½ an inch; so that the inner ends of the second-floor joists in a wooden building constructed in this way would be about ¾ of an inch lower than the

Fig. 104. Correct Method of Building Partitions.

outer ends when the timber had time to shrink. In a brick building the difference in height between the outer and inner ends of the second-floor joists is still greater, as the settlement of brickwork in the height of one story is hardly noticeable. It is from this cause more than from any other that cracks in the plastering of dwellings are so common, and that in partitions running parallel with the joists, the doors will not shut after a year or two. It is not always possible to overcome all settlement from shrinkage, but any considerable settlement can generally be avoided. (See, also, Art. 16.) This is one of the many details in which architects' houses excel those of the speculative builder. If the girder supporting the first

floor had been framed flush with the joists and the second-story studding supported on the cap of the first-story partition, as shown in Figs. 104,* 105 and 106, there would have been only about 15 inches of horizontal wood below the second floor; so that both ends of the joists would have settled about the same amount. Hence in

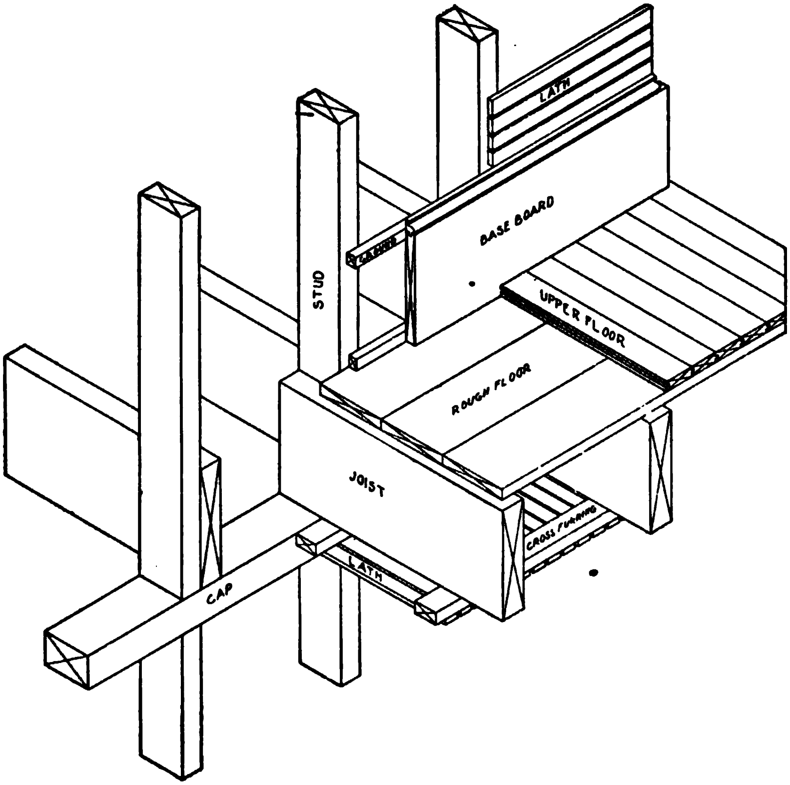


Fig. 105. Continuous Bearing Partition.

all cases where a partition in the second story comes over one below, *the second-story studding should rest on the cap of the lower partition,* and the lower studding should rest directly on the girder, if there is one. If the partitions run the same way as the floor-joists they should be constructed as shown in Fig. 106, the floor-joists next to the partition being kept away 2 inches to afford nailings

* The use of plaster deafening between the over and underfloors is now generally abandoned, as it works loose after a time and the plaster dust is apt to come up through the floor-cracks. It is abandoned in wood mill-floor construction also, as there the plaster dust gradually works down through the flooring-joints and onto the machinery.

for the finished floor-boards. Figs 104, 105 and 106 show continuous bearing-partitions. Figs 107 and 108 show discontinuous non-bearing partitions.

Fig. 106. Two-Story Partition Parallel with Joists.

When the partition does not come over a girder or over a partition it is obvious that it must be supported in some way by the floor-timbers. When the partition runs *parallel with the joists* it is often supported by placing doubled joists in the floor directly under the partition. This method is objectionable, however, for two reasons. (*a*) If the beam thus made is not at least 3 inches wider than the partition it does not give a nailing for the ends of the finished floor-boards; and (*b*) if there are any pipes to be run up in the partition, as is often the case in first-story partitions, the beam must be badly cut into to let them pass. For these reasons it is better to use two joists spaced about 6 inches apart and bridged every 16 or 18 inches with plank bridging, as shown in Fig. 107, the grain of the bridging being *always* horizontal. This gives a good nailing for the floor-boards and allows hot-air pipes to be carried up in the partition without cutting any timber. Fig. 108 shows, also, the doubling of the joists, with a space left between them.

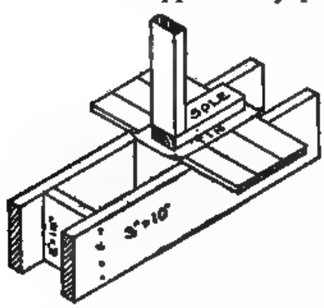


Fig. 107. Partition Suported by Separated Joists

Each of the two joists which support the partition should be at

least 3 inches thick, and in some cases it may be necessary to make them each 4 inches thick, as any bending in them will cause the partition to settle a corresponding amount; and if the partition-bearing joists bend more than the other floor-joists the difference in the amount of deflection will be apparent in the ceiling.

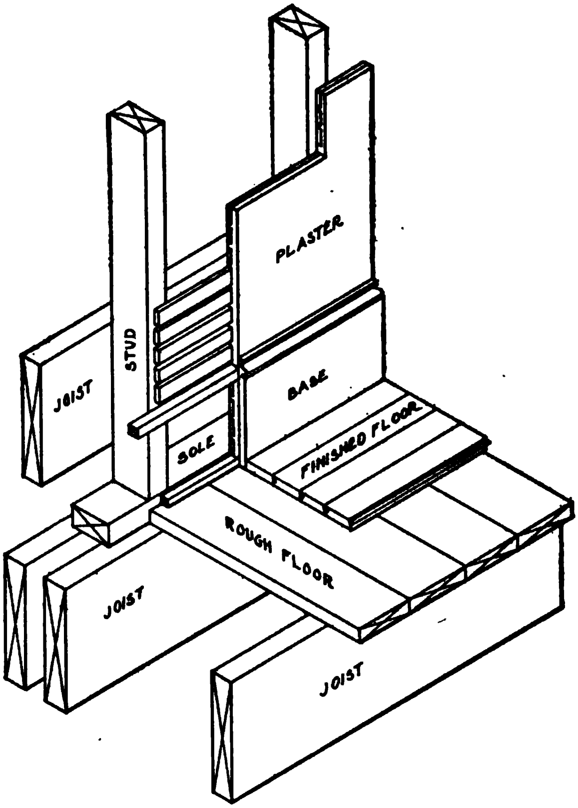


Fig. 108. Discontinuous Non-Bearing Partition.

Whenever a partition rests on top of the beams or flooring it will, of course, settle an amount equal to the shrinkage of the joists; and in brick buildings this is often sufficient to cause a crack to appear at the angle formed by the partition and outside wall.

In first-class brick dwellings, therefore, the only sure provision against cracks is to support all partitions either on steel beams or in the manner shown in Fig. 109, when they cannot be supported on partition-caps. Steel beams undoubtedly make the best supports, but where they cannot be used, either on account of the cost

or the necessity of placing pipes in the partitions, the effect of shrinkage may be overcome by screwing to the bottom of the joists

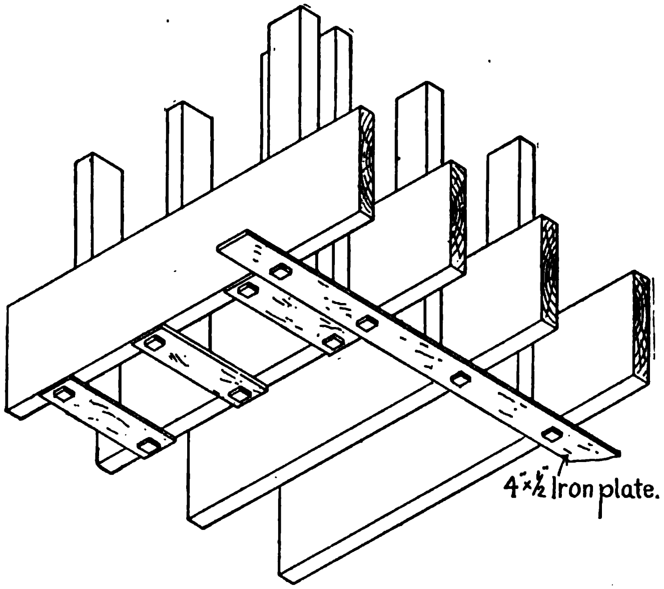


Fig. 109. Supports for Partitions to Prevent Shrinkage-Cracks.

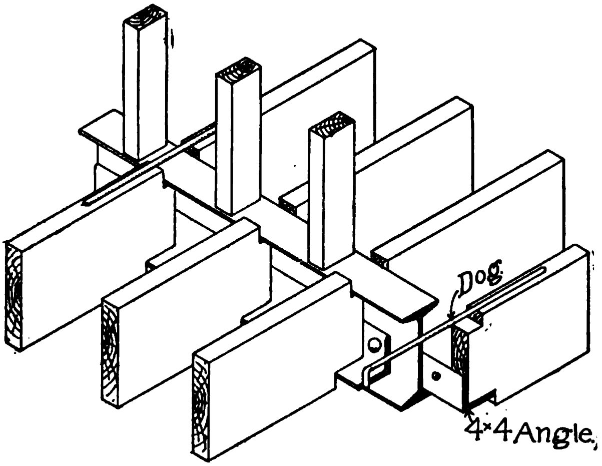


Fig. 110. Supporting Partition on Steel I Beam.

iron plates for the studding to rest on. These plates are about 4 inches wide and ⅜ or ½ of an inch thick and are secured in place with 4-inch lag-screws as shown in Fig. 109.

If the joists are then made of ample strength there can be no settlement in the partitions and consequently no cracks in the plaster from that cause. When the partitions are supported in this way the ceilings should be furred with 1-inch strips for lathing. When steel beams are used they should be at least 1 inch less in depth than the wooden beams to allow for shrinkage in the latter.

When a partition runs at right-angles to the joists, it is generally supported simply by a "sole-piece" laid across the joists or on top

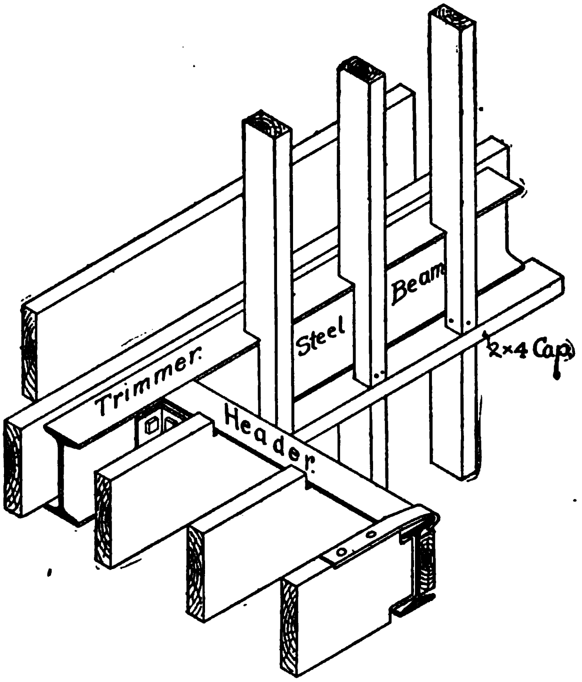


Fig. 111. Framing Supported on Steel I Beams Around Floor-Openings.

of the underfloor, as in Fig. 103; and in this case the joists must be stiff enough to support the *concentrated* weight from the partition. It should be remembered that the load from a partition running at right-angles to the joists and near the middle of the span has *twice* the destructive effect that the same load would have if uniformly distributed; and no increase in resistance is in this case gained by bridging. If there should be wide openings in such a partition, the floor-joists under the studding at the side of the openings should be increased in width or number in proportion to the weight coming upon them. This is an important point in construction and one often overlooked.

108. STEEL-BEAM PARTITION-SUPPORTS. The effect of the shrinkage of the joists on a partition supported in this way is, of course, the same as in the case above mentioned, and it can be counteracted in the same way. If a steel beam is used to support a partition, however, it will be necessary to frame the joists into it, as shown in Fig. 110, or in Figs. 91, 92, 93, 94, 95, 97, 98, 99, and 100.

In first-class brick dwellings all first-story partitions should be supported by either steel beams or brick walls. If the first-story partition supports another in the second story, the beam must, of course, have sufficient strength and stiffness to support all the partitions above it without undue deflection. It is also desirable, in

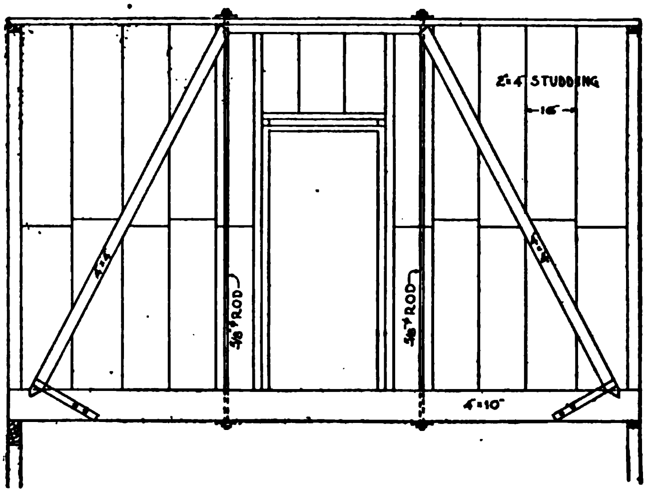


Fig. 112. Trussed Partition.

brick buildings at least, to support the partitions and floor-joists around stairways with steel beams, as shown in Fig. 111.

When a partition is continuous with one below, as is often the case, the studs should be halved over the beam, to the partition-head below, so as to afford a nailing for the laths and to prevent cracks in the plastering.

It sometimes seems necessary to support part of a second-story partition on a partition-cap and part on the floor-joists, but this can generally be avoided by using the plates shown in Fig. 109.

109. TRUSSED PARTITIONS. Where a partition runs parallel with the joists, and comes over a room below of considerable width, it may be prevented from sagging by trussing, as shown in Fig. 112. The extra cost of trussing is very small and by its use sagging can be entirely prevented; and if the rods and

braces are properly proportioned, the partition may be used to support floors or other partitions above. A partition of this kind should be slightly crowned, as the truss is sure to settle a little when the timbers have seasoned. When a truss is employed care should be taken to see that the supports under its ends are ample. Trussing, however, will not prevent settlement from shrinkage unless the bottom member of the truss is thoroughly seasoned.

110. PARTITION-HEADS. The top of all wooden partitions generally consists of a piece of studding called the "cap," which is spiked to the upper end of the studding before the partition is raised. When the partition runs at right-angles to the floor-beams above, the cap is fitted against the under side of the joists. When the partition is parallel with the floor-beams above, and the latter are "strapped" or "cross-furred" underneath, the cap is nailed to the under side of the strapping or furring, as shown in Fig. 106.

If the ceiling is not strapped, then the cap should be secured about every 3 feet by means of cross-pieces, *C*, Fig. 113, spiked between the joists and to the top of the cap. Pieces of boards about 3 inches wider than the cap are then spiked on top of the latter to receive the ends of the laths.

In cheap work the cap *A*, Fig. 113, is sometimes omitted, and the board *B* is nailed directly to the studding, the latter being cut so that the under side of the board is level with the bottom of the joists. The cross-pieces, C. are then nailed above the board.

Fig. 113. Partition-Head, Showing Cap.

When the span of the floor-joists is more than 12 feet, the cap of all bearing-partitions should be 3 inches thick; and if the span is over 16 feet and the studs 16 inches on centers, the cap should be 4 inches thick. In first-class work it is customary to specify long-leaf Southern yellow pine or Douglas fir (Oregon pine) for the partition-caps, as these woods are much stiffer than spruce or white pine and not so apt to warp.

During the construction of a building, precaution should be taken to see that the ends of heavy timbers, or the studs at the sides of wide openings, are properly supported when they come over spaces between the studs below.

111. CORNERS OF INTERSECTING PARTITIONS. The corners of all intersecting partitions should in all cases be made solid, as at *a* or *b*, Fig. 114. The arrangement shown at *a* is the

best, but *b* answers very well if the middle stud is nailed to the horizontal bridging between the other two. In no case should the laths be permitted to run by the end of a partition. Where the

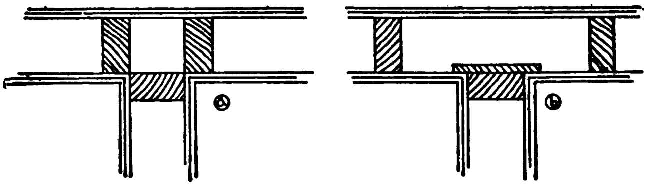


Fig. 114. Joining Intersecting Partitions.

partition joins an outside wooden wall the corners should be made solid in the same way. When the partition comes near the middle of the wall, a 4 by 6 or 4 by 8-inch post should be set in the wall opposite the partition, as shown in Fig. 104.

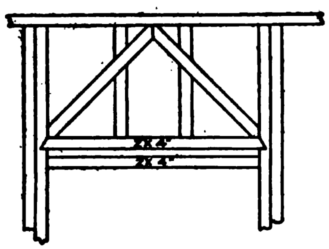


Fig. 115. Trussed Opening in Partition.

Where wooden partitions join a brick wall it is a good plan to bolt the last stud to the wall once or twice in the height of the story by ¾-inch bolts embedded in the wall as it is built. This strengthens the wall and tends to prevent cracks in the angle formed by the partition and wall.

112. TRUSSING OVER OPENINGS. At the sides of all openings in partitions the studs should be doubled, and the partition over the opening trussed, as shown in either Fig. 115 or Fig. 116.

When the opening does not exceed 3 feet, and there is no weight resting on the partition-cap, the trussing may be omitted. The "head" of the opening should always be formed of two pieces, kept 1 inch apart as shown in the figure, so that if the upper one sags it will not affect the lower one to which the door-finish is nailed.

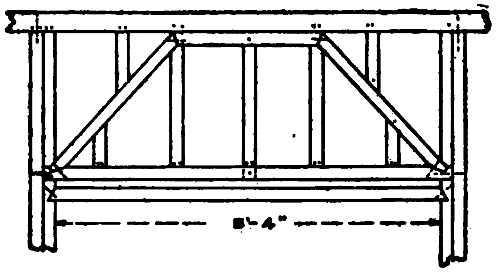


Fig. 116. Truss Over Wide Opening in Partition.

113. BRIDGING PARTITIONS. All partitions should be bridged at least once in their height with 2-inch bridging the full width of the studding. The pieces should be placed horizontally, as shown in Fig. 103. Bridging stiffens the

partition considerably and also prevents the passage of fire or vermin. When a partition is ceiled or wainscoted *flush* with the plaster it is necessary to cut in bridging between the studding to receive the nails.

114. SLIDING-DOOR PARTITIONS. These are made double, the studs being set about 4 inches apart. When 2 by 3 studs can be obtained they are frequently used for these partitions, otherwise 2 by 4 studs must be used, placed either flatwise or edgewise. With studding used the narrow way the partition is hardly stiff enough for stories exceeding 9½ feet in height and should never be used for first-class work. If the partition is a bearing-partition, one side may be made thicker than the other to carry the floor above. It is customary in the better class of buildings to sheath the inside of the partition with thin, matched boarding to prevent the plaster from getting on the tracks or in any way interfering with the working of the doors. This sheathing should be put on when the partition is set up.

115. STAGGERED PARTITIONS. It is desirable that partitions separating two tenements, stores or apartments, shall transmit sound as little as possible. The transmission of sound can be prevented to a great extent by filling the partition-spaces between the studs and laths with mineral wool or with soft bricks laid up in mortar. The best way to obtain this result, however, is to build the partition with two sets of studs, staggered as shown in Fig. 117, the two sets being kept entirely separate and independent of each other. If the two sides of the partition do not connect in any way, or touch each other, there will be very little sound transmitted through the partition. By tacking Cabot's "deadening quilt" to one set of studs the deadening will be nearly, if not absolutely, perfect and the quilt will also, it is claimed, retard the progress of fire. Heavy felt paper may be used instead of the "Quilt," but the author believes that the latter is the better material for the purpose. (See, also, Arts, 140 and 217.)

Fig. 117. Section of Staggered Partition.

116. HOT-AIR PIPES AND PLUMBING-PIPES. The position of pipes of all kinds should be carefully considered in making the plans and provision for them made in framing the partitions and floors. When a 4-inch soil-pipe is carried in a partition the studding must be either 5 or 6 inches wide, or the partition must be furred out around the pipes.

117. FIRE-STOPS. The architect who is mindful of the interests of his client should always take such precautions as he can

to make his building not only strong and durable, but also as slow-burning and inaccessible to vermin as may be practicable. This can be accomplished without much additional cost. One of the best preventives to the progress of fire is the stopping of all spaces between the floor-joists and in the partitions with soft bricks or fire-proof tiles laid in mortar, as shown in Figs. 104 and 106. The spaces between the ends of the first-story joists and over all dropped girders should be filled with brickwork in the same way. This will prevent the rapid passage of fire between the joists from one side

Fig. 118. Fire-Stops in Stucco-Wall Construction.

of the building to the other and up through the partitions. If the partitions are bridged, and one or two courses of bricks in mortar laid on top of the bridging, an additional fire-stop is provided. If a fire can be prevented from ascending in the partitions and spreading between the joists for fifteen or twenty minutes after it is discovered it can generally be controlled and prevented from destroying the building. A partition which rests on the floor, with no partition below, should have a piece of tin, 3 or 4 inches wider than the partition, placed under the sole-piece, as shown in Fig. 107. If the building has a balloon frame, 2 by 4-inch bridging should be cut in between the studs of the outside walls, just below the ledger-board or false girt, and brickwork laid on top to a level at least 5 inches above the top of the joists. This will not only prevent fire

from ascending in the walls, but will prevent the ledger-board from being quickly burnt through. The spaces between the timbers around smoke-flues and all similar places, where fire or mice could pass through, should be filled solid with mortar or mineral wool. In general, fire will not make much headway where there is no draught; and pains should be taken to prevent the passage of flames through the concealed portions of a building. Mineral wool is very efficient for stopping the progress of flames and vermin and also of sound and heat. Fig. 118 shows fire-stops in stucco-wall construction.* The illustration shows the elevation of a part of a partition, with wood studs, bridging, metal lath, plaster and fire-stops of metal lath and plaster. A vertical and two horizontal sections are also shown.

6. ROOF-CONSTRUCTION.

118. PITCHED ROOFS. The proper construction for a roof depends in a great measure upon the shape of the roof, the size and arrangement of the building and the use that is to be made of the enclosed space or "attic." The shape of the roof should be governed principally by the size and plan of the building, the external effect sought and whether or not the roof-space is to be finished. Before describing the methods of construction the various shapes of roofs will be briefly considered and their principal parts defined.

All roofs which have an inclination of 20 degrees or more with a horizontal plane are called "pitched" roofs and those whose inclination is less than this are called "flat" roofs. The "pitch" of a roof is the angle of inclination which the rafters make with a horizontal plane. It is sometimes expressed in degrees, but more often by the proportion which the height in the center bears to the span, or by the rise in inches for each foot of half-span. The last method is the simplest and least likely to be misunderstood and is preferred by the author.

Below are given the rise and angle for the most common pitches:

Two-thirds pitch	rise, 16 ins. in 1 ft.;	angle, 53° 52′
Half-pitch ("square" pitch)	" 12 ins. in 1 ft.;	" 45°
One-third pitch	" 8 ins. in 1 ft.;	" 33° 41′
One-fourth pitch	" 6 ins. in 1 ft.;	" 26° 34′

To obtain the rise of a roof in inches per foot, multiply the pitch, expressed as a fraction, by 24.

* See article in "Architecture," May, 1912, on "Metal Lath in Residence Construction," written by H. B. McMaster, Associated Metal Lath Manufacturers, Youngstown, Ohio.

Fig. 119 is a diagram showing conveniently the wind-pressure for various angles of inclination of roof-surfaces, the percentage of increase of roof-area and of approximate increase in cost from flat to steep roofs, the inclines or pitches expressed fractionally and in degrees and minutes and the rise in inches per horizontal foot. The general form of this diagram is adapted from an original copy-

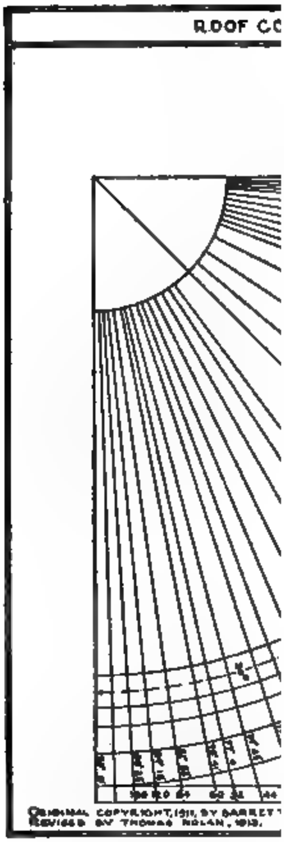


Fig. 119. Diagram for Wind-Pressure on Roofs.

righted diagram loaned through the courtesy of the Barrett Manufacturing Company, New York City.

In deciding the pitch of the roof for any given building the following conditions should be considered: appearance (in connection with the style of architecture), climate, nature of the covering and cost. For dwellings, churches, etc., external appearance generally determines the pitch, while for factories, sheds, etc., the

last two conditions, with the addition of practical requirements, are usually the controlling ones.

High-pitched roofs are considered best adapted to climates which have considerable rain and snow, as in our Northern States, while a low pitch with heavy projections seems most suited to warm climates.

The most economical pitch for small buildings is that which has a rise of about 9 or 10 inches to the foot; and for trussed roofs, a pitch of about 30 degrees. Shingled roofs should have a pitch of at least 6 inches to the foot, except on sheds and porches, where it may, if necessary, be reduced to 4½ inches. Roofs covered with slates of large size may have a pitch as low as 5 inches to the foot, but a steeper pitch is to be preferred. Clay or metal tiles should in general have a pitch of at least 7 inches to the foot and for the most pleasing effect a "square" pitch is generally necessary.

119. TYPES OF ROOFS. The simplest roof is the "lean-to," or "shed"-roof, which has one slope, as shown in Fig. 120. This roof is used principally on sheds, one-story projections and porches

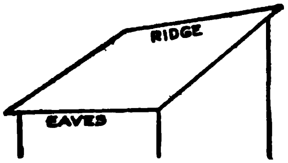


Fig 120. Lean-to or Shed-Roof.

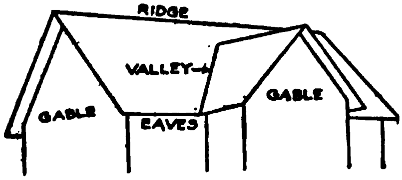


Fig. 121. Gable or V Roof.

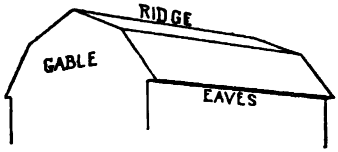


Fig. 122. Gambrel Roof.

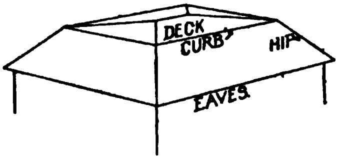


Fig. 123. Deck-Roof.

The roof shown in Fig. 121 is called a "gable," or "V" roof. Next to the shed-roof this is the most easily constructed and the most practical roof for small dwellings. The type shown in Fig. 122 is called a "gambrel," or "curb" roof. It is very commonly seen on buildings of the colonial period and was evidently adopted because of its ample attic-space, without the great height of the V roof. It is best adapted to comparatively wide buildings with finished attics. It requires less lumber and covering-material than the V roof for the same span and gives about the same amount of available space inside. The "Mansard," or "French" roof, is like

the gambrel roof, except that the first pitch is steeper. The Mansard roof generally slopes from all four sides of the building.

When a roof slopes back from the ends of a building, as well as from the sides (Fig. 124), it is called a "hipped" roof, and when it terminates in a flat roof, as in Fig. 123, it is called a "deck"-roof. Considering the saving in the gable-walls, a hipped roof is cheaper than a gable roof, and when the width of the building is

Fig. 124. Roof-Framing. Common Method.

over 30 feet a deck-roof is still cheaper. Hipped roofs and deck-roofs are commonly used on large buildings. Mansard roofs are often used on large dwellings and also on hotels and office-buildings.

120. ORDINARY ROOF-CONSTRUCTION. The common method of framing wooden roofs is illustrated in Fig. 124. The timbers which support the roof-boarding are called "rafters" which are supported at or near the lower ends by the "wall-plates" and at the upper ends by the "ridge-pole" or by another rafter. At all ridges or valleys larger timbers are placed to receive the ends of the roof-boards, and also of the short pieces of rafters. The timbers under the hips and valleys are called "hip-rafters" and "valley-rafters," respectively, and the rafters which cut against them are called "jack-rafters." When the length of the rafters is over 18 feet they should be supported somewhere near the middle of their span. In dwellings this is generally done by means of studs or partitions, but sometimes by "collar-beams." In larger buildings the center support is furnished by means of "purlins" resting either on trusses or on posts set over the interior walls or columns.

121. LAYING OUT ROOF-PLANS. To lay out a pitched roof for an irregularly shaped building so that it will look well and properly support itself and the loads liable to come upon it, requires some experience. The method which the author has always fol-

lowed in designing a pitched roof, where a building has an irregular plan, is to draw an outline-plan of the walls and on this to construct the greatest rectangle that can be inscribed in it. This rectangle can then be covered with a hipped roof to which the various projections are subordinated.

Thus, in Fig. 125 is shown the outline of a building which is to be covered with a pitched roof. The greatest rectangle that can be drawn within these lines is indicated by the letters *a b c d*. From the corners of this rectangle lines are drawn at 45-degrees until they intersect and the two points of intersection are joined. The 45-degree lines represent the hips of the roof and the connecting line the plan of the ridge. The length and position of these lines in

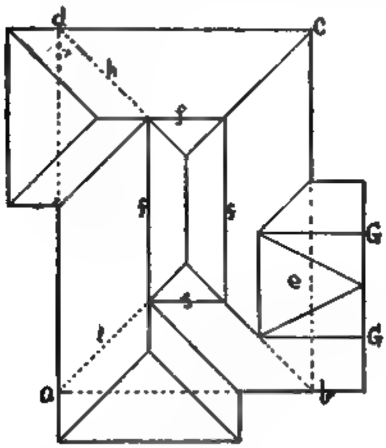


Fig. 125. Method of Laying Out a Roof-Plan.

Fig. 126. Framing-Plan of Roof of Ordinary Dwelling.

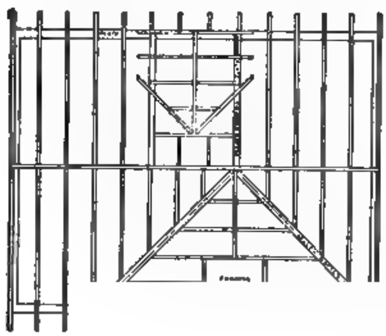
the roof-plan will be the same for any degree of inclination of the roof, provided all parts of the roof have the same pitch. Having obtained the lines of the main body of the roof, the roof-lines of the various projections are drawn, all of them, at first, for hipped roofs. Afterwards the hip-lines are erased and the ridge extended if a gable is preferred. The lines of the main hips below the intersections of the subordinate ridges, as at *h* and *i*, should also be erased. If the width of a projection is so great that its ridge comes too high up on the main roof, such projection can be roofed by a double gable, as at *G G*, or by two three-quarter gables. The portion of the roof *e* between the gables will, of course, have a much flatter pitch than that of the gable roofs themselves, but it is not usually seen from the ground.

If a deck is designed it can be indicated by drawing a rectangle,

f f, between the hip-lines at any desired point above the subordinate ridges.

Although the roof-plan shown in Fig. 125 is a comparatively simple one, the method used in laying it out can be extended to the most complicated plan, provided the plates are all on the same level. If part of the roof starts from a different level the plan must then be worked out in connection with the elevations.

122. FRAMING-PLANS. After the lines of the roof have been decided upon, a plan of the framing-timbers should be drawn. The hips and valleys are drawn first and then the common and jack-rafters, leaving proper openings for chimneys, dormers, etc.



Unless there is some special reason for doing otherwise, the common rafters should be drawn perpendicular to the walls and ridges, as this brings a large part of the weight of the roof directly onto the walls; and the boards, being put on horizontally, furnish a support or stage for the workmen.

Fig. 126 shows the framing-plan of an ordinary house-roof, the common and jack-rafters being indicated by single lines and being spaced 16 inches on centers. Fig. 127 shows a roof-plan with a gable and hip and a dormer piercing the side of the gable part.

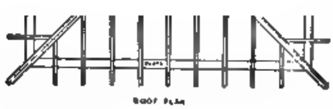


Fig. 127. Roof Framing-Plan, with Gable, Hip and Dormer.

The spacing of the common rafters varies much with the custom of the locality; in some places 16 inches is the usual spacing and in others from 20 inches to 2 and even 3 feet. When the spacing is only 16 inches the rafters are often lathed on the under side; but when it exceeds that distance the rafters must be furred for lathing. It requires less lumber, including even the furring-strips, to obtain the same strength and stiffness, for a roof with rafters spaced 2 feet on centers than for a roof with rafters only 16 inches on centers. In Boston the usual spacing of roof-rafters for dwellings is 20 inches on centers, and in Denver, Colo., 16 inches; but in the latter city the attic lathing is applied directly to the rafters, while in Boston the laths are nailed to furring-strips. The Boston method

results in more even surfaces and is the most economical construction as far as material is concerned; but it involves a little more labor than the Denver method.

123. DETAILS OF ROOF-CONSTRUCTION. If a roof is less than 30 feet in span and the plates are securely tied by the attic-floor joists, no interior supports are needed, as the roof can always be framed so as to be entirely supported by the walls. The common rafters should be at last 2 by 6 inches in cross-section for lengths of 12 feet, 2 by 8 for lengths from 12 to 18 feet and 2 by 10 for lengths over 18 feet. As a rule it is cheaper to reduce the span of the rafters to 10 or 12 feet by using purlins or partitions for supports than to use heavier rafters.

Each rafter should have a bearing on the wall-plates of at least 2½ inches for 6-inch rafters and 3 or 4 inches for 8 and 10-inch rafters; and they should also be securely spiked to the plates.

At the ridge the rafters should be spiked to a plank, as shown in Fig. 124. Very often this plank is omitted and the upper ends of each pair of rafters are spiked together, or secured by a short piece of board nailed across the ends, as shown in Fig. 129. While this method gives sufficient strength, it is more apt than the former method to result in a crooked ridge.

The upper edge of each hip-rafter should be beveled to fit the plane of the roof on each side of it.

If the wall-plates are 3 feet or more above the attic floor, the rafters or plates should be tied to the floor-joists by inclined braces or ties, as shown in Fig. 128. These ties may be of 1-inch boards, but should be securely nailed at each end with tenpenny nails and spaced not more than 3 feet apart. They should not be placed at a greater angle than 45 degrees with the floor-joists. The longer the tie the greater its efficiency.

In a roof such as is shown in Fig. 126, with a principal rectangle the extreme width of which is 30 feet or less, the only pieces requiring especial strength are the valley-rafters. These timbers have to support nearly all the weight of the roof above them and should be calculated accordingly. One of each pair of valley-rafters should be extended to the main ridge, or to a hip-rafter, as shown in Fig. 126 at *d* or *b*, and also in Fig. 124. If this is not done there will be no support for the upper end of the valley, unless a post is put in the attic for that purpose. In roofs of moderate size, when a main hip is intercepted by a subordinate ridge, as at *h* and *b*, Fig. 126, it is customary to stop the hip at the ridge and spike the two together; but in large roofs the hip should be extended to the plates, as at *b c*, and the rafters cut against it.

A roof framed as in Fig. 126 will be entirely self-supporting with-

out interior supports. The hip-rafters, in roofs having plates well secured and tied, are supported by the common rafters, and do not need to be of extra size. It is easier, however, for nailing and for beveling the top if they are made 2 inches deeper than the jack-rafters. Openings for dormers should have double or triple rafters at each side and a header at the top, proportioned to the sizes of the openings and the area of roof to be supported.

124. SIZES OF SPECIAL TIMBERS TO BE CALCULATED. It is impossible to give any rules for the size of special timbers, such as valleys, headers, etc., either in roofs or floors, other than those for the strength of beams. It is often the custom merely to make such timbers double or triple the size of the common rafters or joists; but such practice is no better than guesswork and the young architect should early accustom himself to calculate the necessary sizes of such timbers for the weight they have to support.

In computing the strength of inclined beams to support a vertical load it is sufficiently accurate to take the horizontal projection of the beam for the span, using the same formulas given for horizontal beams.

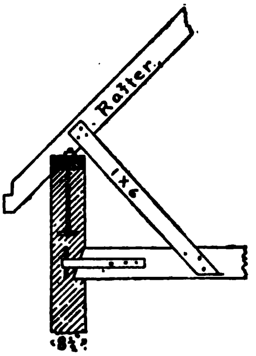


Fig. 128 Tying Rafters to Floor-Joists.

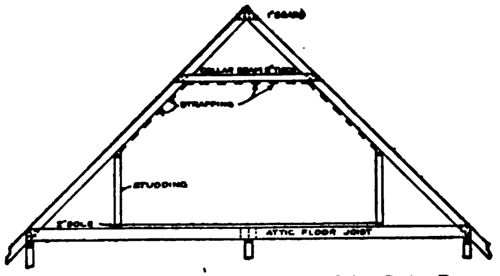


Fig. 129. Pitched Roof Strengthened by Collar-Beams.

125. COLLAR-BEAMS. A pitched roof is greatly strengthened by nailing "collar-beams," or horizontal beams, across each pair of rafters at a height of 8 or 9 feet above the attic floor, as shown in Fig. 129. These collar-beams prevent the rafters from sagging, and, if the attic is to be finished, serve also as ceiling-beams. The rafters are usually strengthened, also, by studding set in 3 or 4 feet from the plates to form the walls of the attic rooms.

126. CURB ROOFS AND MANSARD ROOFS. 1. *Various Types and Forms.* The form of curb roof known as the "Mansard" is supposed to have been invented by François Mansard, a distinguished French architect of the seventeenth century. Roofs

of this shape afterward became very common in France and they are therefore often referred to in this country as "French roofs." Curb roofs were very commonly used on the early colonial buildings of this country, but they were quite different in their proportions from the French type. The colonial curb roof received, also, the name "gambrel roof."

By means of a Mansard or curb roof the same amount of available space may be obtained more cheaply than by means of a gable roof. The outward thrust on the walls is not as great with a Mansard roof as with a pitched roof. On the other hand, Mansard roofs, where they stop on top of the wall, are open to the objection that the gutters are not so easily freed from snow. Such roofs are considered more inflammable, also, than roofs of one-half or less pitch.

The New York and Chicago building laws require that roofs whose inclination to the horizontal is greater than 60 degrees shall be of fire-proof construction, except (in New York) on wooden buildings or dwellings less than 40 feet in height.

The curb roof is frequently used in this country on dwellings, and particularly on those in the colonial style. The Mansard was the prevailing type of roof for pretentious dwellings built forty years ago; but it is little used to-day except occasionally on city dwellings built in blocks and on public buildings. In regard to the proportion or pitch of Mansard roofs there appears to be no recognized rule.

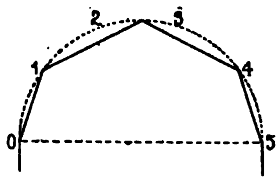


Fig. 130. Method of Determining Outline of Gambrel Roof.

Rivington's "Notes on Building Construction," Part II, gives the method shown in Fig. 130 for determining the outline of a curb or Mansard roof. A semicircumference is described on a horizontal line connecting the wall-plates and is divided into five equal parts. The chords, 0 1 and 4 5, give the lower lines of the roof while the upper lines are obtained by drawing chords from 1 and 4 to the middle point of the semicircumference.

If the angles of the roof happen to lie in the curve of a parabola, instead of in that of a semi-circle, the beams will, theoretically, be in equilibrium; that is, the outward thrust of the upper rafters will be just balanced by the inward pressure of the lower ones. But as any inequality in the loading, or the least wind-pressure, immediately disturbs the equilibrium, this consideration is not of much practical importance.*

As a matter of fact, the outline of both Mansard and curb roofs is

* See "Hip and Jack-Rafters" and "Spans for Rafters." "Architects' and Builders' Pocket-Book," by F. E. Kidder.

generally determined by considerations of exterior design, although the pitch of the upper portion depends somewhat upon the roof-covering, a rise of 6 inches to the foot being the least that should be given to roofs that are to be covered with slates or shingles.

For curb roofs the outlines shown in Fig. 131 may be considered as representative of American practice. Diagram *A* is the outline of one end of the Governor Brooks house, built in 1764, at Medford, Mass., and is fairly typical of the roof-outlines of that period. Diagrams *B* and *D* are taken from modern colonial houses having two stories below the roof; and diagram *C* is the outline of a one-story house designed by Mr. W. R. Emerson. Diagram *E* shows the outline of the wings of the Garden City Hotel, built at Garden City, N. Y., and designed by McKim, Mead & White.

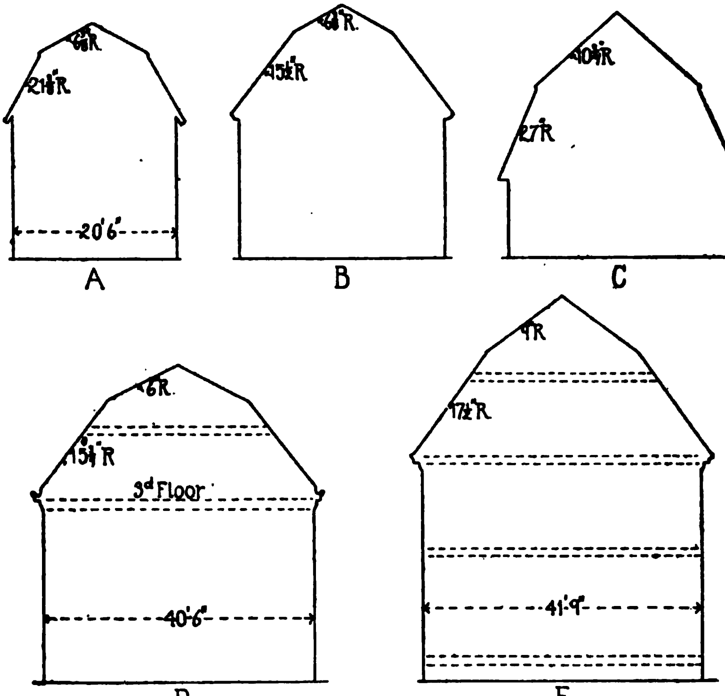


Fig. 131. Outlines of Gambrel Roofs. American Practice.

The numbers shown in connection with the roof-lines indicate the rise of the roof in one foot of horizontal projection.

Diagrams *A, B, C* and *D,* Fig. 132, and section *C,* Fig. 134, are representative outlines of Mansard roofs used on dwellings in this country forty years ago. Diagram *E,* Fig. 132, is typical of the modern

Mansard roof, the curved outlines being now seldom used, except on some recent public buildings.

City houses built in blocks, when surmounted by Mansard or steep-pitch roofs, generally terminate in an ornamental cresting, as shown at *E*, Fig. 132, the main roof being covered with tin or gravel roofing and pitching toward the rear of the house. Very frequently a balustrade or parapet is placed above the wall-cornice and in front of the base of the roof. Mansard and curb roofs are almost invariably pierced by dormers.

2. *Details of Construction of Curb and Mansard Roofs.* The construction of curb roofs is usually quite simple, the common

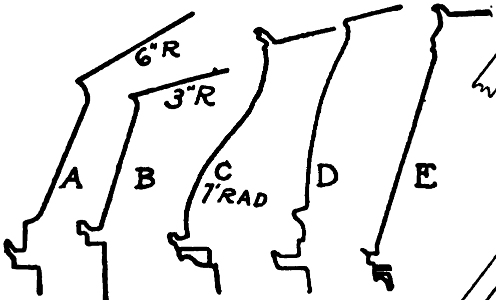


Fig. 132. Outlines of Mansard Roofs.

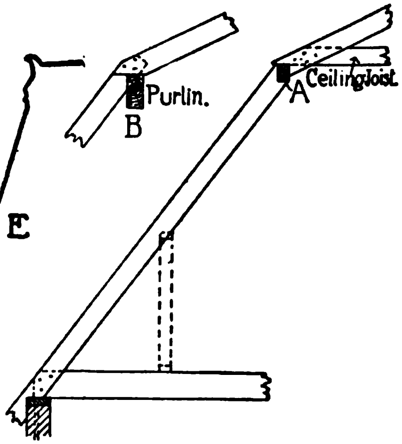


Fig. 133. Construction of Common Type of Gambrel Roof.

method being about as indicated in Fig. 133. The wall-plates may be either just below the attic joists, as shown, or they may be above the joists; but they are seldom more than 2½ feet above the joists, as it is desirable that the dormer-windows shall come above the plates. If the plates are above the attic-floor joists, the latter should be anchored to the walls if of brick, or well spiked if of frame, and the wall-plates bolted to the walls, or well spiked to the top of the studding if of frame, as the plates are depended upon to resist the outward thrust of the lower rafters.

Where the two sets of rafters meet at the curb, a plate or purlin, at least 4 by 6 inches in cross-section, should be placed, and the upper end of the lower rafters cut so that the latter will support the plates. These plates should receive the upper rafters, and, if the height of the attic story permits, the ceiling joists also.

If the attic ceiling comes below the curb-plates the rafters may be

supported by purlins as shown at *B*, Fig. 133. These purlins should be tied together across the roof at least once every 14 feet. A roof framed as shown in Fig. 133, without any cross-partitions, would be likely to collapse in a severe gale or from a heavy weight of snow on one side only; hence, if the roof-space is not divided in length

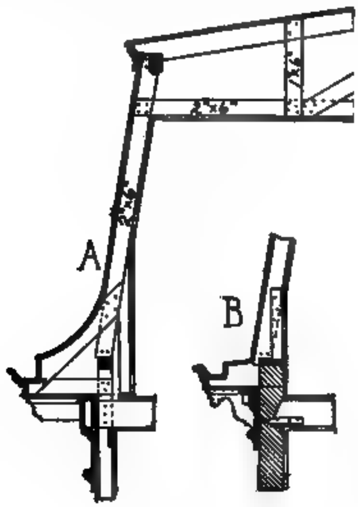


Fig. 134. Detail of Mansard-Roof Construction.

by cross-partitions, bracing should be employed. As a general rule such roofs are further stiffened by dwarf partitions, as shown by the dotted lines.

Fig. 135 shows various types of curb or gambrel roofs with details of the construction and finish. Roofs of this type which have a pitch of less than 22 degrees for the upper, flatter part should not have the latter covered with slates, shingles, or other lapped materials liable to leak because of the backing up of the water under the lap on the too flat surface.

The construction of Mansard roofs depends, in a great measure, upon the outline. Fig. 134 shows the construction of two of the most common shapes. In both roofs shown in these drawings the weight of the roof is carried directly to the wall-plates, the 2 by 4-inch uprights, in section *C*, being considered merely as a partition or furring, which could be entirely omitted if desired. The curve of the roof should always be formed with 2-inch furring-pieces built out from the straight rafters, carrying the weight of the roof and resting on the wall-plates. The wall-plates should not be more than 2½ feet above the floor-joists and should be so secured that they cannot spread.

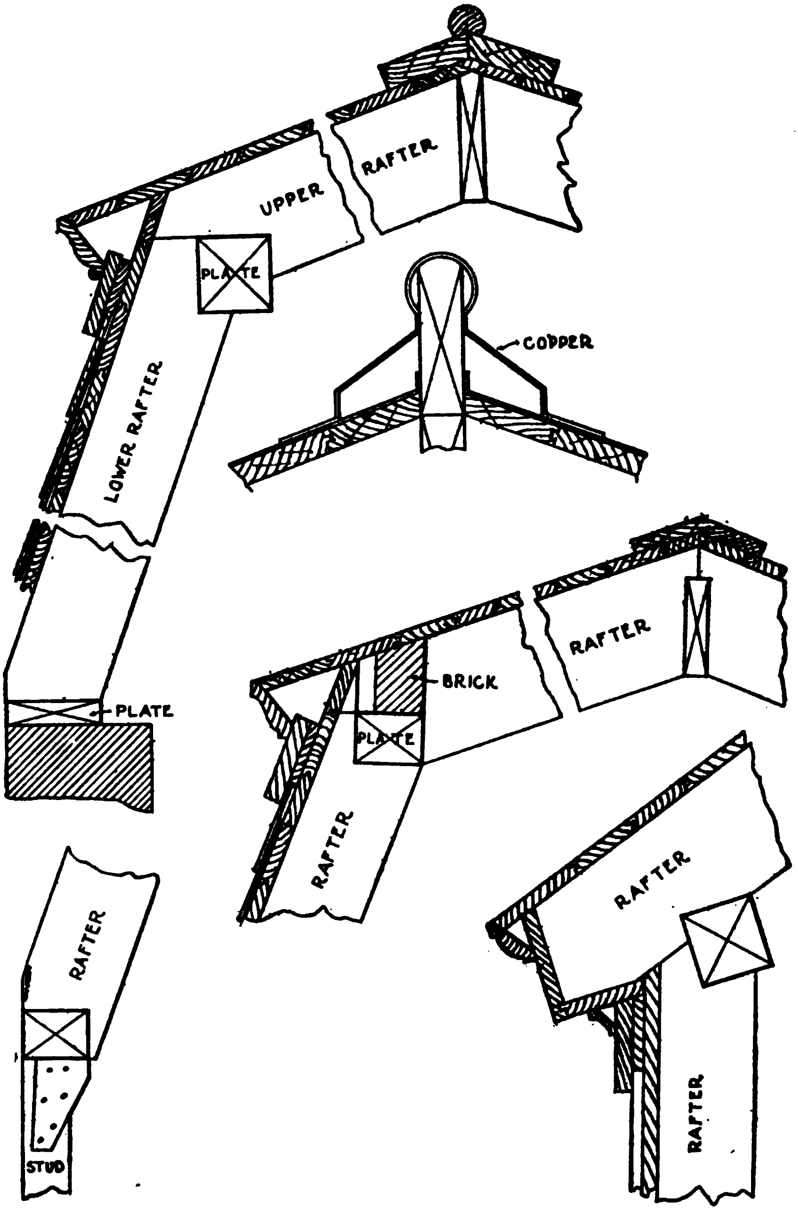


Fig. 135. Details of Construction of Gambrel Roofs.

Mansard roofs are generally accompanied by heavy, projecting cornices, which, if of wood, may be formed as shown in Fig. 134. The cornice at *B* is supported by plank "lookouts" built into the walls and secured by spikes driven through the plates. These lookouts may be from 2 to 3 feet apart.

127. CONICAL ROOFS. Small conical roofs, such as are frequently used on small circular towers, are best framed as shown in

Fig. 136. Framing for Small Conical Roof.

Fig. 137. Framing for Bell-Shaped Roof.

Fig. 136. The plates should be cut out of wide planks and always made of two thicknesses put together so as to break joint. When well spiked together, they form a continuous ring to resist the outward thrust of the rafters. The rafters should be spaced at even distances apart, about 3 feet at the bottom, and circular ribs cut in between them every 20 or 24 inches on the slant. If the diameter is more than 10 feet it is not necessary to carry all the rafters to the peak, some being terminated under one of the circular ribs, as shown at *A*. For small roofs it is necessary to cut the boards to a wedge-

shape and put them on vertically, nailing them to the circular ribs. Larger roofs may be covered with ¾-inch boards bent around the roof at an angle of 45 degrees with the plates. In this way the boards do not have to be cut to a pattern and the ribs or "sweeps" are not required, except to secure the upper ends of the short rafters, as the boards are nailed to the rafters.

128. BELL-SHAPED ROOFS. If the vertical section of a roof is bell-shaped, instead of conical, furring-pieces cut to the desired curve should be spiked to the top of straight rafters, as shown in Fig. 137, and circular ribs cut in between, as in conical roofs. If the roof is very high, or has a finial, the upper end of the rafters should cut against a center pole, having as many sides as there are rafters. This pole stiffens the roof and forms a support for the finial. It is also well to brace the lower end of the pole by cross-pieces spiked to the rafters and to the pole.

129. DORMERS.* These should be framed generally as

Fig. 138. Framing Dormer-Window.

shown in the section-drawing, Fig. 138. An opening of the proper size to receive the dormer should be framed in the roof, as shown in Fig. 126, and the studs of the dormer should be notched out 1 inch over the roof-boarding and under the trimmer-rafter and ex-

* See, also, Art. 198.

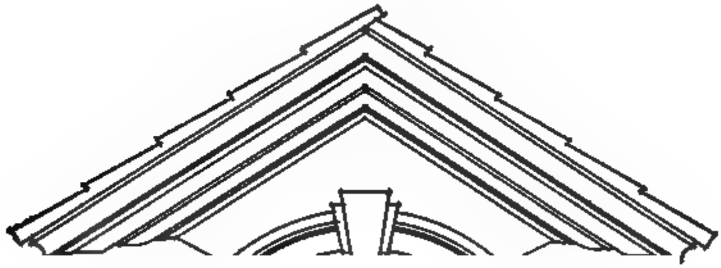


Fig. 139. Details of a Dormer-Window Designed by D. Knickerbacker Boyd.

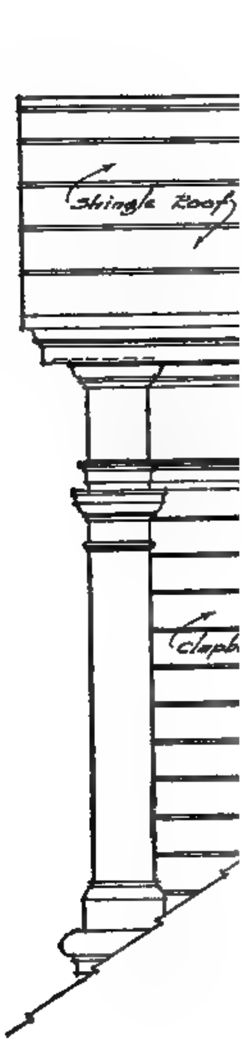


Fig. 140. Details of a Dormer-Window Designed by D. Knickerbacker Boyd.

tended to the floor. Notching the studding around the rafters prevents the roof from sagging or breaking away from the sides of the dormer and thus causing a leak; and the studs being extended to the floor stiffen the trimmer and form a continuous surface for lathing without fear of plaster-cracks. An enlarged section through the dormer-sill is given in Fig. 138, showing one method of flashing. The flashing in this example is laid over the upper course of shingles, and a wedge-shaped piece fitted between the sill and flashing and toe-nailed into the sill. This keeps the flashing in place and almost conceals it. The upper end of the flashing should be securely nailed to the back of the sill.

On Mansard roofs the front of the dormer generally comes over the wall, the front studding thus resting on the wall-plates; the studding forming the sides may, in this case, be spiked to the top of the trimmer rafters.

Figs. 139 and 140 show the elevation, plan and section of a dormer-window for a frame residence, designed by D. Knickerbacker Boyd. The elevations of the front and side of the dormer are shown, the sides being covered with clapboards and the roof being shingled. The horizontal section or plan shows the general construction of the outside-finish and inside-finish and of the box window-frames and sashes and indicates clearly the provision made for the introduction of outside fly-screens. The vertical section shows further details of these same parts and also the construction of the roof, gable, window-head and sill. The upper sash and the head are finished "square" on the inside so that roller shades may be used; and blocks are shown on pulley-stiles to prevent the sash-fast or the top of the lower sash itself from striking the shade when this sash is raised. As the detail shows, the architect has not only arranged for all these necessary conveniences but has been very successful in designing a wooden dormer that is absolutely weather-proof. The greatest difficulties to be overcome in this respect are in connection with the construction of the window-sill, which in this example has been made in two pieces to avoid the "checking" incident to the use of one wide piece of wood. The construction has been made weather-proof by the very thorough flashing of the sill as shown, which flashing forms a sort of metal pan arranged under the entire sill and brought down well onto the roof-shingles, along the entire extent of the front. The ends of the sill and all clapboards at the point of contact with roof and pilaster are flashed individually with metal and all stand clear of the roof-shingles. The other details of the design of the dormer-window, not mentioned in this brief description, are clearly shown in the drawings.

Fig. 141 * and Fig. 142 * show details of a dormer window on the roof of a brick house designed by Richard Arnold Fisher.

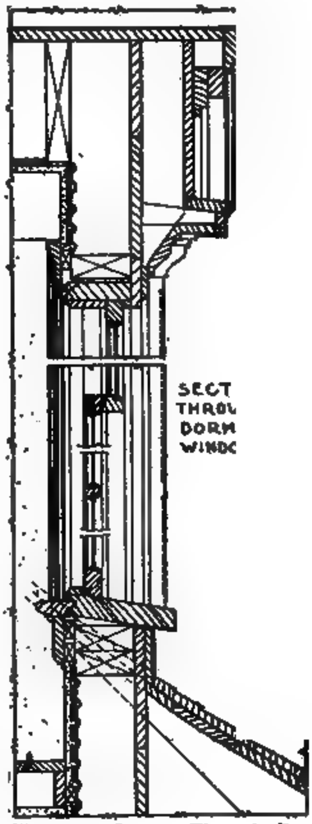


Fig. 141. Section Through Dormer-Window.

1. *Eyebrow Dormers.* Fig. 143 † shows the details of construction of an eyebrow dormer-window, *a* being the half-elevation, *b* the section showing the general construction and *c* the section through the window-frame. As usually constructed, these windows are apt to be ungraceful in general appearance. If carefully studied, however, in regard to their curves and proportions and if the reverse-curves are made to die away into the roof-lines without breaks or humps, their design can be made quite pleasing. They are ordinarily used to light and ventilate unfinished attics.

130. ROOFS OF WIDE SPAN. When the span of a roof exceeds 30 feet, either trussing or interior supports should be used, so that the unsupported length of the rafters will not exceed 12 feet. The roofs of dwellings can generally be sufficiently supported by carrying up partitions or by the use of collar-beams. It often happens, however, in a large house that the attic space is used for a ball-room or some similar purpose in which the room, posts or other supports for the roof are very objectionable. In such cases the roof can generally be supported by one of the methods described below.

1. *Hip-roof Trussing for Wide Spans.* Any room not exceeding 40 by 60 feet in area can be safely covered by a hipped roof without trusses or interior supports of any kind, provided the plates are made continuous around the four sides of the main roof. Fig.

in Fig. 141.

* Figs. 141 and 142 and some others are redrawn, adapted and used by permission from "Building Details," by Frank M. Snyder.

† This drawing and several others are by permission redrawn, adapted, and rearranged from "Details of Building Construction," by C. A. Martin.

144 represents the plate-hip-rafters and deck-beams of a hipped roof, terminated by a deck. It is readily seen that such a construction is practically a truss in itself, and that if the several pieces are properly proportioned and connected it will carry an enormous weight and exert a vertical pressure only, on the walls.

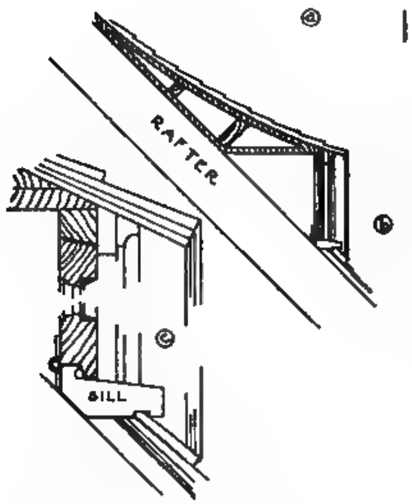


Fig. 143. Framing of Eyebrow Dormer. *a*. Elevation. *b*. Section. *c*. Detail.

As ordinarily constructed the hips and plates of such a roof are made light and carry practically no load at all; but if all the common rafters and jack-rafters are spiked to the deck-beams and the hip-rafters so securely that the rafters have no tendency to slide or push out at the bottom, the weight of the roof will be thrown largely on the hips and there will be no outward thrust on the plates. The thrust of the hips will be taken up by the plates and the walls under the plates will sustain the vertical load. The hips and deck-beams must be of such size that they will not sag under their load and the planks forming the plates must be fastened so securely, by tie-irons at the angles, that the hip-rafters cannot force them apart. No dependence should be placed upon the common rafters for the support of the hips and deck-beams. If the roof is to be carried to a ridge it can be extended above the deck-beams, the latter forming, as it were, a new plate. In such cases, however, there should be collar-beams between the deck-beams to prevent their being pushed in.

A roof built in this way is entirely practicable, and the author has often employed this method in constructing hipped and "octagon" roofs. If carefully built and proportioned, this construction can

be used where there is no ceiling at the plate-level; but in such cases the plates should be made as wide as possible, not less than 12 inches, for example, when 30 feet in length. It is obvious that if the angles of the plates should give way the whole roof would fall.

If there are projections and minor roofs they can be built onto

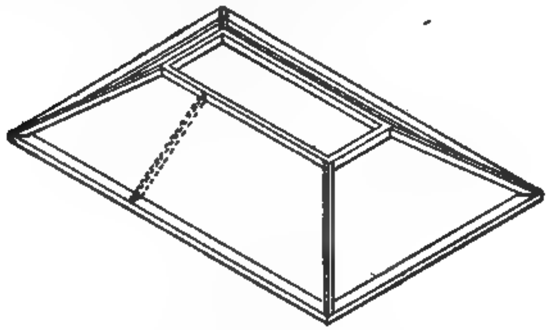


Fig. 144. Outlines of Hip-Roof for Wide Span.

the main roof and will strengthen it against spreading; but the main frame must be built as in Fig. 144, with the plates *continuous* around it. If the plates are interrupted by chimneys, they should be connected by iron ties passing either through or around the chimney.

2. *Supporting Rafters Without Trusses.* When it is desired to

Fig. 145 Framing Rafter-Supports Without Trusses.

support the rafters of a roof without using trusses, some method of framing, similar to that shown in Fig. 145, can often be adopted with advantage. Purlins are placed under the rafters about half-way up and supported by braces as shown, pieces of boards or planks being nailed to the rafters and against the purlins, as at *A*. The pairs of braces should be spaced about 8 or 10 feet apart longi-

tudinally of the roof and the purlins proportioned according to the length of the rafters and distance between the braces. If there are no ceiling-joists, tie-beams must be used, spaced the same distance apart as the braces, to keep the plates from spreading; and the plates must be of such width that they will not bend horizontally between the tie-beams. Such construction is well adapted for the roofs of pavilions, depot-platforms, etc., when the span is from 30 to 35 feet, and center posts are not objectionable.

7. SUPERINTENDENCE OF THE FRAMEWORK.

131. SUPERINTENDENCE OF WOODEN BUILDINGS.

1. *Framing-Drawings.* If complete framing-plans have been furnished for the walls, floors and roof, the superintendence of this part of the building will be quite an easy matter, as the work is fully exposed and open to inspection.

2. *The Lumber.* The first thing to attend to is the inspection of the lumber, to see that it is of the kind and quality specified and of the proper dimensions. The superintendent should be sufficiently familiar with the woods specified to distinguish the different kinds at a glance. The differences in the texture or color of white pine, Norway pine, Douglas fir, hemlock, spruce and hard pine are usually sufficient to readily determine these woods, although occasionally there are pieces of hemlock which are difficult to distinguish from spruce, and Norway pine sometimes closely resembles white pine. Familiarity with the peculiar odors of these different woods is often an assistance in distinguishing them, a fresh sliver being cut for purposes of comparison.

It is not so easy to distinguish between the different varieties of spruce and hard pine; and if two varieties of the same species are in the market, one of which is particularly desired, it is generally necessary to ascertain from the lumber-yard which variety is furnished, or to call in expert advice. The defects to be looked for are shakes, longitudinal cracks, bad knots and pieces that are badly warped. Shaky pieces (Art. 17) should always be rejected. Small longitudinal cracks in large timbers are to be expected. They do no great harm, especially if in the top or bottom of the timber; but in thin pieces, such as 2-inch joists, longitudinal cracks, especially if below the center, are sufficient cause for rejection. Pieces that are badly warped and pieces with large or dead knots should be rejected. Small, sound knots are admissible in ordinary framing-lumber, as it is difficult to obtain such lumber without them. Large timbers, with a considerable proportion of sap-wood, should not be used where they are subject to great stress, or where ample ventilation is not provided.

In regard to size, framing-timber generally measures from ¼ to ½ of an inch scant, of the nominal dimensions, and such differences must be expected and allowed for unless one cares to pay for having the lumber sawed to order.

3. *Bedding the Sills.* The first step in the erection of the frame of a wooden building is the placing of the sills, and if on a brick or stone wall the superintendent should see that they are properly bedded in mortar. It is a good practice, although not a common one, to paint the bottom of the sills before setting them on the walls. This is done to keep out the dampness, the sides and top being left unpainted so that the moisture will dry out.

4. *Size and Position of Openings.* As the framework progresses the superintendent should verify the principal dimensions to see that they agree with the drawings, for, while the builder can be held responsible for his mistakes, it is very annoying, to say the least, to discover after the frame is up that the building does not correspond with the drawings; and the owner is usually inclined to think that the architect should have prevented the error.

The most frequent mistakes are those which are made in locating the openings for doors, windows and chimneys. The openings for the chimneys, especially, should be measured to determine if they are large enough for the chimneys to pass through and at the same time leave a 1-inch space between the chimney and the headers and trimmers. They should be exactly located, as the variation of even an inch will often affect the appearance of the room to which they belong.

5. *Supports for Partitions.* When the floor-joists are being placed the superintendent should see that the timbers which are to support partitions are of the designated size and that they are put in their proper places. He should also look at the framing around all openings to see that the headers and trimmers are of the proper size and that the different pieces have been properly mortised together or supported by metal joist-hangers, according to the specifications.

6. *Constructional Details.* While the outside frame is being erected the superintendent should see that the posts are plumb, the girts placed at the proper height, all the braces put in and the whole properly mortised and pinned together.

7. *Roofs.* The principal points to be looked after in the roof-frame are the pitch, the way the valley rafters are put in and the size and position of the dormer-openings.

Carpenters are sometimes liable to make the pitch a little less than that indicated on the drawings, as the flatter the pitch the less the amount of lumber required; hence the necessity of seeing that

the pitch is the same as that indicated on the drawings. It can easily be determined by means of a two-foot rule and a plumb.

The superintendent should see that the valley-rafters are extended to the ridges, or hips, as explained in Art. 123. This is not always done.

In order that the studding of the dormers may be notched onto the rafters, as explained in Art. 129, it is necessary that the trimmer-rafters be spaced very accurately and the superintendent will do well to carefully verify the measurements.

All parts of the roof should be well spiked together, particularly at the plates, ridges, hips and valleys. The ridges should be perfectly straight and level and exactly in the center. The tops of the rafters should all lie in the same plane and not be "hunched up" or allowed to sag.

8. *Partitions.* The superintendent should see that every partition is set in its proper place and that the studs are straight and plumb and of uniform width. Crooked studs may be straightened by cutting them with a saw on the bulging side and then spiking them together again; or a stud may be cut in two and a cross-piece or header put in between the adjacent studs. The bearings of the partitions should correspond with the specifications and the studs at the sides of the door-openings should be strongly supported. Very often such studs, which, if in a bearing-partition, are quite heavily loaded, come over the center of the space between the studs below, the whole weight, perhaps, being borne by a 2 by 4-inch cap. In this case a brace should be put in below or the plate should be reinforced. The superintendent should examine all corners to see that they have been made solid for lathing, see that provision is made for running furnace-pipes, and see that all openings are properly trussed.

9. *Bridging.* As soon as practicable after the floor-joists have been placed and before the underflooring is laid or the partitions built, the floor-bridging should be put in and securely nailed with two tenpenny nails in each end of each piece.

132. SUPERINTENDENCE OF BRICK BUILDINGS, The framing of the floors, roofs and partitions of brick buildings is the same as for wooden buildings, with the exception of the wall-plates and the anchoring of the floor-joists. As has been explained in Arts. 96 and 97, the anchoring of the floor-joists to the walls in brick buildings is a very important matter and should be carefully looked after by the superintendent, who should see that the bolts for the wall-plates are built into the walls at the proper height. If the partition-studs are to be bolted to the walls the superintendent should see that the bolts are provided by the carpenter and built

in by the brick-mason at the proper time, otherwise they are very apt to be overlooked.

While many of these precautions may seem rather unnecessary, unless the superintendent fixes them well in mind and realizes their importance, he will be likely to find, as the building progresses, that he neglected to look after them at the proper time; and that some things have been overlooked or improperly done which by a little thought and care on his part, might have been attended to. If, as is the usual custom, the architect supervises his own work, inspecting it once every day, or every second or third day, as may be necessary, he will find it of great assistance in his work to make a memorandum from the specifications of the things to be looked after before visiting the building, and then to examine these matters in a certain definite order when making his inspection.

CHAPTER III.

Sheathing, Frames, Sashes, and Glazing.

I. SHEATHING.

133. ROUGH BOARDING. 1. *Side Walls.* As soon as the walls of a frame building are up they should be tightly covered with common boarding, or "sheathing," as it is called in many localities.* For this purpose the cheapest kind of lumber may be used: hemlock, spruce and western white pine being most commonly used in the North, hard pine in the Southern and Gulf States, and redwood, Douglas fir, western hemlock, spruce and western white pine on the Pacific Coast. For the better class of buildings the boards should be dressed on one side to bring them to a uniform thickness and should be free from shakes and large knot-holes.

When the braced frame is used it is customary to sheath the first story before the second-story studding is set up. The sheathing or boarding should be nailed at each bearing with two tenpenny nails, although eightpenny nails are often used. If the building is constructed with a balloon frame, without braces, it is necessary to put the boarding on diagonally in order to secure sufficient rigidity in the frame. With the braced frame diagonal sheathing is not necessary, although it makes a better job than results from horizontal sheathing. All towers, cupolas, etc., should be sheathed diagonally.

2. *Roofs.* In covering the roofs of either wood or brick buildings, two methods are pursued: in the first the roof, like the walls, is tightly covered with dressed boarding; and in the second, narrow boards, sometimes called "laths," are nailed to the rafters horizontally, with a space of 2 or 3 inches left between them. The latter method is presumed to make the more durable roof, as it affords ventilation for the shingles and makes them last longer. With such a roof the attic is warm in summer and cold in winter, and is objectionable on this account if the attic is to be finished. Most architects prefer to cover the roof with boarding laid close and then to lay tarred paper over the latter and under

* See "Rules for Estimating Quantities of Sheathing" and "Cost of Sheathing." "Architects' and Builders' Pocket-Book." F. E. Kidder.

the shingles or slates. This not only protects more efficiently the attic space from changes in temperature, but also prevents fine snow from sifting in under the slates or shingles. The specifications should distinctly mention whether the boards are to be laid close together or laid "open," and also the kind and quality of the boards themselves.

For shingle roofs it is not absolutely necessary that the boards be dressed, even on one side, if they are of uniform thickness; but the dressed sheathing makes a neater job and costs very little more.

Roofs that are to be tinned should be covered with matched boards, dressed on one side, so as to present a smooth surface for the tin. All knot-holes should be covered with pieces of heavy galvanized iron. All rough edges, also, should be smoothed off with a plane. The object of these precautions is to prevent the tin from being injured by persons walking across the roof where the edges of the boards are turned up or where there are knot-holes.

2. WINDOW-FRAMES.

134. GENERAL REQUIREMENTS. The first work of the carpenter or joiner usually required in connection with either a frame or brick building is the making of the basement window-frames, the coal-chute and the outside basement door-frames, if

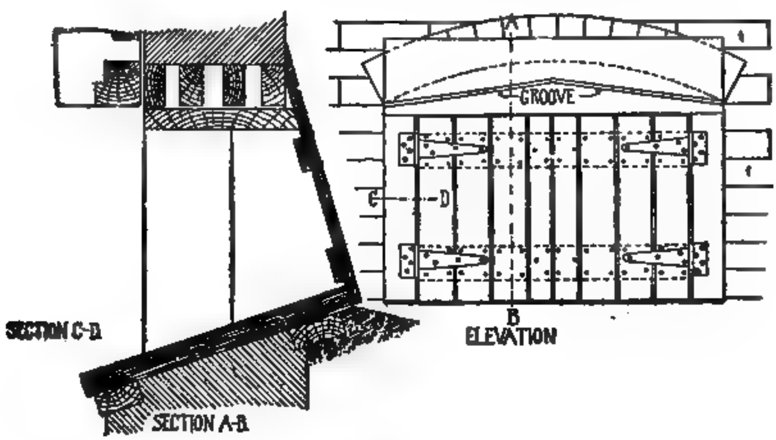


Fig. 146. Coal-Chute Construction.

there are to be any, as all of these are generally built into the walls as they progress.

135. COAL-CHUTE. As nearly every house that is heated by hot air, steam or hot water must have a coal-bin in the basement, an

opening for putting in the coal is a necessity. Very often an ordinary cellar window is utilized for this purpose; but where there is room it is better to construct a regular coal-chute. An ordinary window-frame soon becomes marred or loose and the glass is frequently broken. This is especially true when soft coal in large lumps is used.

The author has found the construction indicated by the section and elevation drawings of Fig. 146, the most satisfactory and durable. It also presents a fairly neat appearance. The frame is made entirely of planks, those forming the bottom running *across*

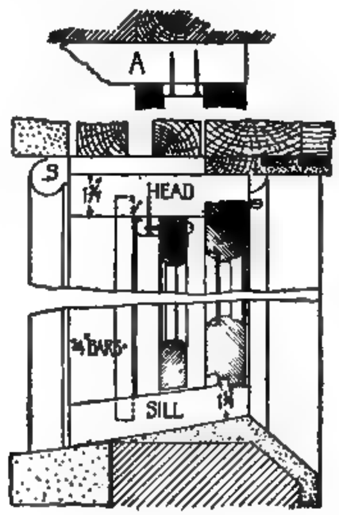


Fig. 147. Cellar Window-Frame in Frame House.

Fig. 148. Cellar Window-Frame in Frame House.

the wall instead of longitudinally with it, as in the sills of window-frames. The bottom of the frame should project 6 inches beyond the outside of the wall, to give the doors a slope outward, and also to make it easier to put in the coal. The outside of the plank frame should be cased with ⅞-inch finished lumber, as shown in section *C D*, and the doors made of "ceiling," * strongly battened and put together with screws or clinched nails. They should be hung with T hinges, and may be fastened with hooks and staples on the inside. Pieces of studding should be nailed to the ends and bottom of the frame to hold it in the wall.

136. CELLAR-WINDOW FRAMES. These are almost invariably made of planks and each is usually fitted with a single sash

* The term "ceiling" as used in this book refers to matched and beaded boards; in Boston and possibly elsewhere, the term "sheathing" is used to denote the same thing.

varying from 16 to 24 inches in height and from 30 to 36 inches in width, hinged at the top to open in.

Fig. 147 shows sections through the sill and head of a cellar window as ordinarily constructed for a frame house, although in the very cheapest work the jamb and head are sometimes made without a rebate, a strip called a "stop" being nailed to the frame for the sash to strike against. A molding, *S*, is generally nailed to the outside edge of the frame to make a tighter joint between the frame and the masonwork. This molding may be of various shapes, but a better joint is made when it has a quirk on the outer edge. In

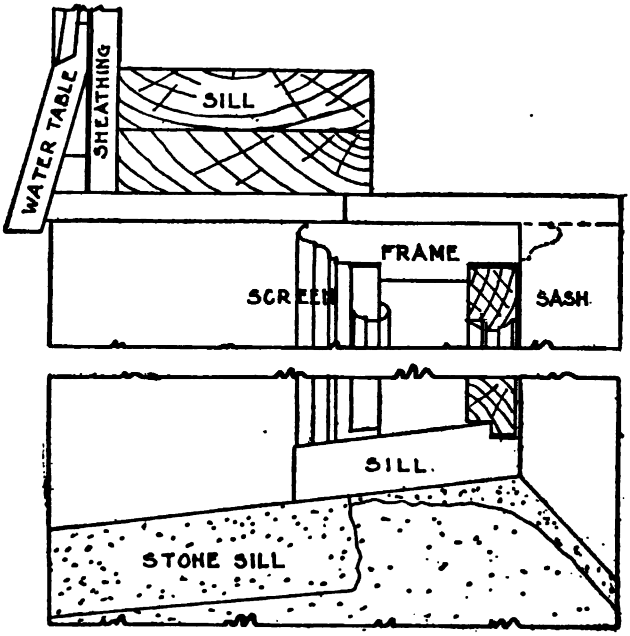


Fig. 149. Cellar Window-Frame in Frame Cottage.

all frames built into stonework or brickwork this molding is called the "staff-bead," or, in some localities, the "brick-mold." The head and sill should project beyond the sides or "jambs," so as to form "lugs" for securing the frame to the wall, and the jambs should be let into them ½ an inch.

The frame shown in Fig. 148 is in one or two details a better construction. The most important of these is the shape of the sill, which makes a tighter joint than that shown in Fig. 147. This frame is also provided with vertical iron bars, placed about 4 inches apart, as a security against burglars. The fly-screen is put in from

the inside. The section through the side of the frame is the same as that through the head.

The detail at *A*, Fig. 148, shows a section sometimes used for the jambs and heads of cellar window-frames. When the jamb is in one piece, however, it is apt to warp away from the masonry, and, in the opinion of the author, this is not as good construction as that in which a separate staff-bead is used. It is a good idea to nail 2 by 2-inch strips to the back of the jambs of all plank frames, as shown at *A*, to hold the frames securely in the walls.

Fig. 149 * shows a detail of a cellar-window frame and of the adjoining parts of a frame cottage. The water-table, sheathing, sill-timbers and stone slip-sill are clearly shown. Fig. 150 shows

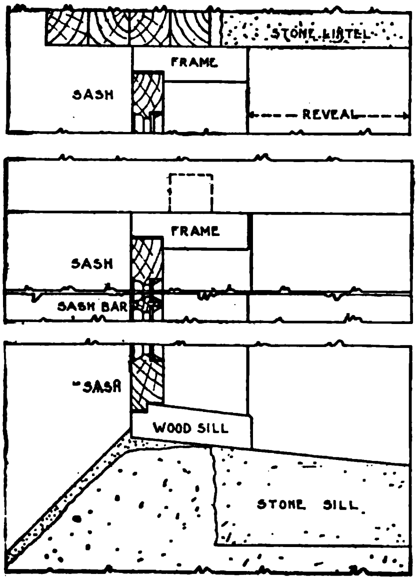


Fig. 150. Cellar Window-Frame in Masonry Wall.

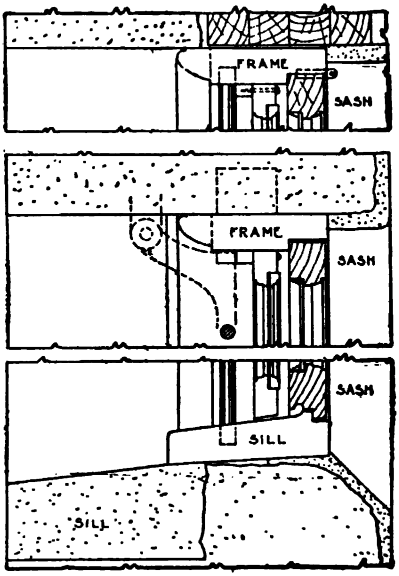


Fig. 151. Cellar Window-Frame with Screen and Iron Grille in Masonry Wall.

details of the sill, sash-bar, jamb and head of an ordinary cellar window in a masonry wall. Fig. 151 shows the details of sill, jamb and head of a cellar window in a masonry wall, with screen and iron grille. An alternate arrangement for a hinged grille is shown by the dotted lines in the jamb-section.

137. TYPES OF WINDOWS. Before proceeding further with the details of window-construction, the various types of win-

* This detail and several others are by permission adapted, redrawn and rearranged from "Details of Building Construction," by C. A. Martin.

dows commonly found in American buildings are briefly considered.

The most common type in use in this country is the "double-hung" window. This has two sashes, each one-half the height of the window, and each hung with cords and weights or fitted with sash-balances, so as to slide up and down. The essential features of this window are the same in both frame and brick buildings, although the difference in the character of the walls necessitates some variation in the construction of the frames.

Drawing *A*, Fig. 152, shows an elevation of a double-hung window in a frame building, with two styles of head-finish; and drawing *B* shows an elevation of the same window placed in a brick wall.

There are also several variations of this type of window, a very common one in brick buildings being that shown at *G*. Where the window has a circular head there are two methods of constructing the upper part of the frame and sash. One is to make all but the outside portion of the frame square, with square, solid corners to the upper sash, so that it will slide up and down and be finished on the inside the same as though the window had a square head. The other method is to make a solid circular head to the frame, so that it will finish circular in form on the inside. The latter method generally results in a better appearance on the inside, especially when the window has no curtains or draperies; but a serious objection to it is that the lower sash can slide only to the springing of the circle, and the upper sash, having but a small portion of its sides straight, does not usually work well. For these reasons it is generally better to adopt the former method of construction for circular-head windows in residences, hotels, club-buildings, etc.

Frequently in brick buildings the top of the upper light of glass, and also the outside of the frame, is cut in the form of the segment of a circle, in which case it is called a "segment-head" window. Segment-head windows are usually finished "square" on the inside.

Double-hung windows are also often made with the division between the sashes at some point above the middle, so as to bring the meeting-rail above the height of the eye of a person looking out from the inside; and when this is done it is necessary to make a "pocket" above the head of the frame for the lower sash to slide into, if it is to slide its full height.

Double-hung windows are also frequently used in pairs, as shown at *C*, Fig. 152, and sometimes three or four windows are included in the same frame. A window such as is shown at *C* is called a "mullion-window" or a "double window," the vertical division between the windows being called a "mullion." This window has also a

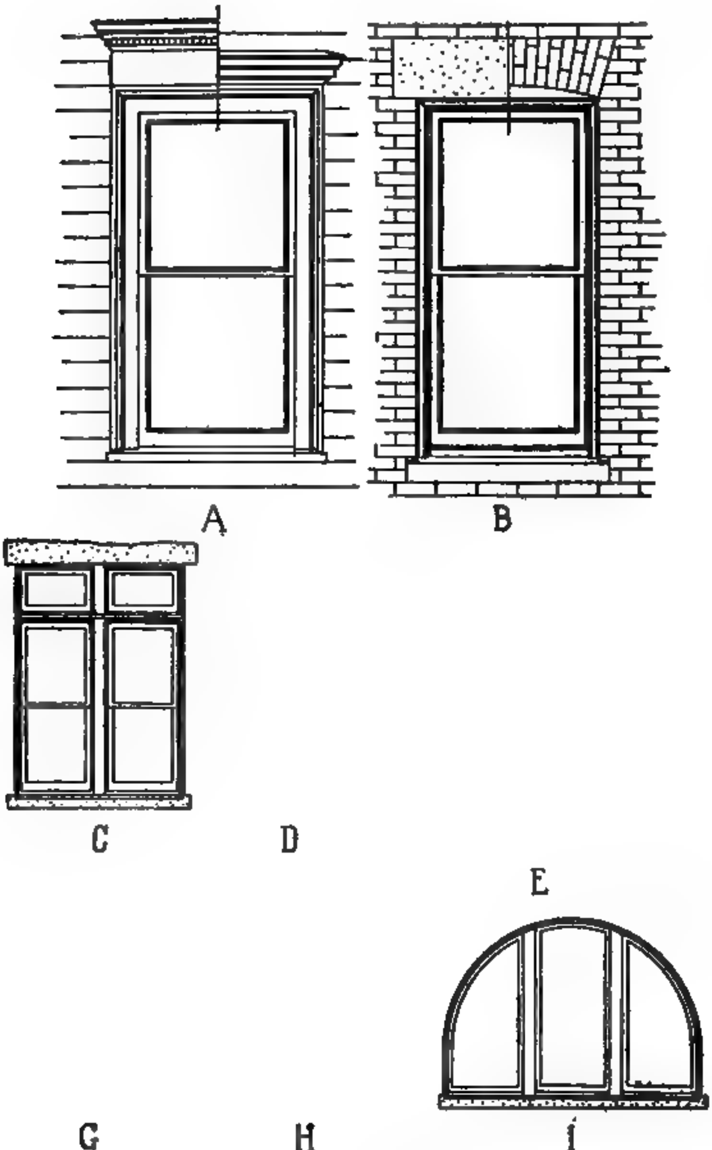


Fig. 152. Types of Windows.

"transom bar," which is the horizontal division between the double-hung sash and the small sashes, or "transom-lights," above. Transoms are frequently used where there are no mullions, and *vice versa.*

Stone mullions and transom-bars are also frequently used to divide windows, as shown in drawing *E,* which represents, also, a special type of the double-hung window.

Next to the double-hung window, in regard to general use, comes the "casement-window" or "French window" shown at *D.* This window has the sashes divided vertically, each being hinged at the sides like a pair of doors. Transoms are frequently, although not necessarily, used with this style of window. The casement-window is the common type of window in Europe, but it has serious objections which make it undesirable for general use. The most important of these objections are that if the sashes swing in, it is difficult to make them storm-proof, and also that they interfere with the shades and draperies; and, on the other hand, if they swing out, fly-screens cannot be used on the windows.

Besides these two types of windows there are others in which the sashes are pivoted, either at the center of the sides, or at the top and bottom. Windows of the shape shown at *I* are frequently seen in large buildings. The sashes in these windows, if they open at all, are usually pivoted at the top and bottom.

Then, too, there are the tracery-windows used in churches, and they are of great variety in their shapes and proportions.

138. CONSTRUCTION OF WINDOWS. *Materials Used.* A window may be said to consist, in general, of three parts, the frame, the sash and the inside finish, and each part is usually described separately in the specifications. The material for all those parts of the frame which are exposed to the weather should be white pine, Douglas fir, cedar, larch, sugar pine, cypress or redwood. White pine has always been generally preferred where it could be obtained at the desired price.

The piece called the "pulley-stile" is frequently made of hard pine, and sometimes of one of the broad-leaved hardwoods, because such woods wear better under the friction of the sash in sliding up and down. Whether of hard or soft wood, the pulley-stile should never be painted, but simply oiled or stained. The concealed portions of the frame are usually made of spruce, the cheaper grades of white or yellow pine, or the most common wood of the locality. All of the material should be well seasoned, and in order to keep out the dampness, frames that are to be placed in masonry walls should be painted or oiled all over before they are set.

139. DOUBLE-HUNG WINDOW-FRAMES FOR FRAME

BUILDINGS. 1. *General Methods of Construction.* The common method of constructing the window-frames in wooden buildings is shown by horizontal and vertical sections in Fig. 153. Such frames are frequently called "skeleton frames," to distinguish them from the "box frames" used in brick and stone buildings. The essential parts of such a frame are the pulley-stile, *A*, the parting-strip, *E*, the outside casing, *B*, the stop-bead, *S*, the head and the sill. A band-molding, *C*, sometimes called the "outside architrave," is also necessary if the casing is flush with the boarding; but if the casing is set outside of the boarding, the molding is often omitted. The inside casing or trim, *D*, is a part of the inside finish, and not usually considered a part of the frame. Very frequently, in cheap work, the tongue on the edge of the pulley-stile, at *R*, is omitted and the casing, *B*, simply nailed to the pulley-stile. This tongue, however, is a very important feature, as it prevents the pulley-stile from warping or springing, and allows the sash to slide more freely. It is better to make the tongue on the inside face of the stile. The construction shown in Fig. 153 may be considered the very cheapest and is not recommended for good work.

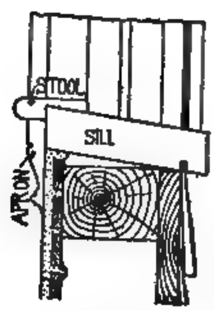


Fig. 153. Double-Hung Window-Frame. Cheap Method.

Fig. 154. Double-Hung Window-Frame. Better Method.

In all first-class dwellings the sill should be made about as shown in Fig. 154, that is, with a rebate at *K* for the bottom rail of the sash to shut against; and a ground-casing, *G C*, should be nailed to the inside edge of the pulley-stile. It is not common, however, for builders to include these two features unless they are specified. The ground-casing stiffens the pulley-stile, keeps it straight, and affords a better nailing-space for the finish. If 1¾-inch sashes are to be used, as they should be in first-class work, and if the studding is 4 inches wide, the outside casing should be placed outside of the boarding, so as to make the pulley-stile wider. This leaves room for a strip, *S*, to which the guide for the fly-screen, *F S*, may be fastened. When there are outside blinds, with swivel-slats, and also

outside fly-screens, some such arrangement as this is almost necessary. If the inside finish is to be of hardwood, the ground-casing should be rebated for a thin strip, *V*, which should be put in after the plastering is dry. With the outside casing set outside the boarding the band-mold or architrave is not really necessary, unless ⅜-inch shingles are used on the walls; but it relieves the plainness of the frame and is generally used on good work.

In frames made as in Fig. 154, it is advisable to hang a "pendulum" or thin partition between the weights to prevent their interfering in passing up and down. This pendulum consists of a strip of ⅜-inch pine, or other suitable wood, as shown in Figs. 156, 158, etc., and is hung from the top so that it may be swung to one side in order to get at both weights through one pocket. In all double-hung window-frames a piece about 18 inches high, 2¼ inches wide and with beveled ends, should be cut out of the lower part of the pulley-stile to give access to the weights. This piece is called the "pocket" and is held in place by a screw at the lower end and by a brad, or dovetailed arrangement, at the upper end.

Fig. 155 shows a section through the head and sill of a still more elaborate frame. The sill has an additional rebate under the sash, intended to prevent the lower sash from getting "stuck," and also to keep out rain and snow. This rebate is seen, however, in only a few localities. The rebate at *N* is intended to form a stop for the bottom of the blinds and is a desirable feature. This detail shows a heavy outside architrave, the inner edge being flush with the inside face of the blinds and forming a rebate for them to shut into, and it makes a very neat finish for a window. It shows, also, a different arrangement of the window-stool, which is dropped ½ an inch below the top of the sill. The stop-bead is carried across the sill. This makes a good finish but not as wide a stool as results from the construction shown in Figs. 153 and 154. If the finish is to be painted the sill is brought flush with the inside of the ground-casing and the piece *V* omitted. With hardwood finish the stop-bead and the piece *V* are made of the same wood as the finish. In first-class buildings the "stop-bead" should be fastened with round-headed screws, which may be of any desired finish; while in common work small "finishing nails" are used.

Fig. 155. Head and Sill of Double-Hung Window Frame.

2. *Thicknesses of Parts.* All parts of window-frames except the "sills" and "yokes" are commonly made of ⅞-inch stuff. For large windows the "pulley-stiles" should be 1⅛ inches thick, and if no strip is inserted between the outer sash and the casing, the latter, also, should be 1⅛ inches thick. In wooden buildings the sill should always be at least 1¾ inches thick. Sometimes a "sub-sill" is placed under the regular sill, but this is not common, as its introduction is no advantage in ordinary construction.

Fig. 156. Double-Hung Window-Frame. Frame Wall.

The "parting-strip," *E*, Fig. 153, is usually made ⅜ of an inch thick for 1⅜-inch sashes and ½ of an inch thick for 1¾ or 2¼-inch sashes. The "yoke" is made from ⅞ to 1¼ inches thick, according to the custom of the locality. A thickness of 1⅛ is just as good as 1¾ inches. The "stool-molding" is generally made ⅞ of an inch thick in moderate-priced houses in the Eastern States. In the

(a) (b)

Fig. 157. Double-Hung Window-Frames. Frame Walls. *a. b.* Different Types.

West, however, $\frac{7}{8}$-inch boards are very seldom thicker than $\frac{3}{4}$ of an inch when dressed and $1\frac{1}{8}$-inch "stools" are used there altogether. The depth of the "weight-box" should be 2 inches for $1\frac{3}{8}$-inch sashes of moderate size; while for plate-glass windows and large windows with double-strength glass, the minimum depth should be $2\frac{1}{4}$ inches.

Fig. 158. Double-Hung Window-Frames. Frame Walls.

Fig. 156 shows the jamb of a double-hung window with screen attached, in a frame wall. The detail of the frame is somewhat more elaborate than usual. Fig. 157, *a* and *b*, shows two varieties of double-hung windows in frame walls. The sill, jamb and head are shown in both cases. Fig. 158 shows other variations, in two sets of details, with sill, jamb and head, for double-hung windows in frame walls. Fig. 159 * shows other methods of constructing double-hung window-frames. Detail *a* shows a "half-timber" fin-

* Although the window-frame details for frame and brick walls are in general described separately in different articles, it is occasionally more convenient to consider some types together as in this illustration. (See Art. 141.)

ish on a masonry wall; *b* and *d* a similar finish for a frame wall; *c* shows a plaster finish on a masonry wall; and *e* shows a comparatively inexpensive and very good construction sometimes used for windows in thin brick walls or brick-veneered walls. Figs. 160 *, 161 * and 162 * show isometric perspectives of window-frames in

(e)

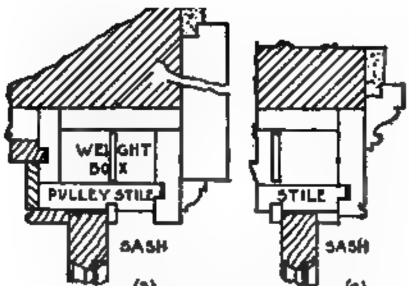


Fig. 159. Jamb-Details of Double-Hung Windows. *a*. "Half-Timber" Finish on Masonry Wall; *b*, and *d*. Same for Frame Wall; *c*. Plaster Finish on Masonry Wall; *e*. Finish for Thin Brick or Brick-Veneered Walls.

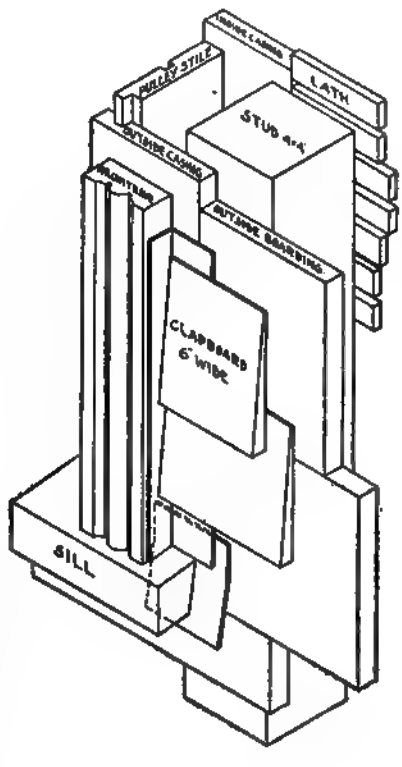


Fig. 160. Window-Frame in Frame Wall. Outside View.

frame walls. Fig. 161 shows the upper part of the frame and its relation to the trim and wall-framing and Fig. 162 shows the same

* These Figures as well as some others have been adapted and redrawn by permission from the plates of "Construction Details," by F. W. Chandler.

for the construction about the sill. The relations of the various parts are clearly shown.

140. SHEATHING-PAPER AND FLASHING. 1. *Sheathing-Paper.* When the outside casing is set flush with the boarding the band-mold or outside architrave, *C*, Fig. 153, should be put on after the frame is fixed in place. The sheathing-paper should be extended onto the casing and the molding *C* nailed over it and over the joint between casing and boarding. If the casing is set outside the boarding, the sheathing-paper should be put on around the opening before the frame is put in place, and the outside casing should be nailed over it. (See, also, Arts. 192 and 220.)

2. *Flashing.* When the band-molding or the casing is tightly nailed over sheathing-paper no flashing is needed on the sides when the wall is covered with siding or clapboards; and if good, thick, tough paper is used the flashing may be omitted for shingles also, although it is much safer to flash each course of shingles with pieces of tin, as shown in the figures. The top of the

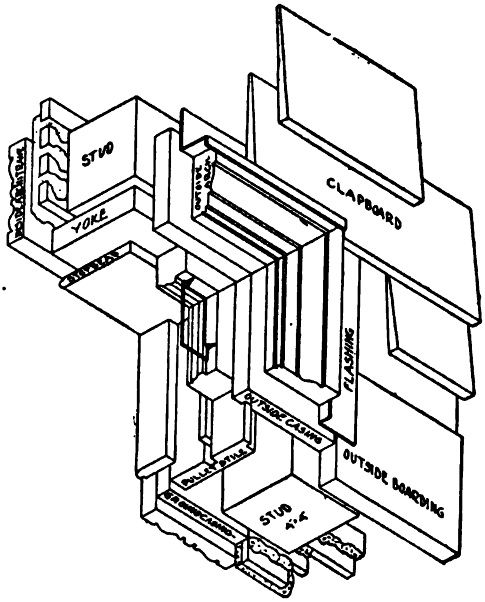


Fig. 161. Window-Frame in Frame Wall. Upper Part.

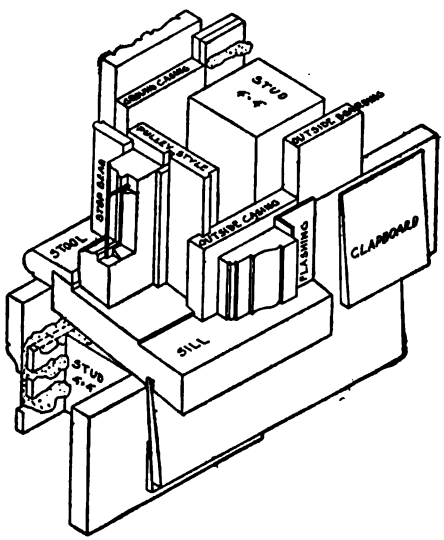


Fig. 162. Window-Frame in Frame Wall. Lower Part.

frame, however, should always be flashed, no matter how it is made, unless the shingles project over the casing. The best materials for this flashing are lead and zinc, although tin is often used. The flashing should be turned over the edge of the casing or band-mold, as at *F*, Fig. 155, and securely tacked or bradded. The bottom of the sill should be rebated for the shingles or clapboards, as shown in the figures. (See, also, Arts. 185 and 187.)

141. DOUBLE-HUNG WINDOW-FRAMES FOR BRICK BUILDINGS.* About the only difference in the construction of

Fig. 163. Box Frame for Double-Hung Window in Masonry Wall.

Fig. 164. Box Frame for Double-Hung Window in Thick Masonry Wall.

the window-frames in a brick building from those in a wooden building, is that an additional board, *B L*, called the "back lining," Figs. 163 and 164, is nailed to the back of each frame to form a box for the weights; and a molding or strip, *S*, is nailed to the outside casing to make a finish with the brickwork. From the fact that a complete box is formed for the weights, frames made as in Figs. 163 and 164 are commonly called "box-frames." The pulley-stile, *P*, outside casing, *O C*, and yoke are the same as in a wooden building. The wooden sill of a box-frame, where a stone sill is used, is frequently made no thicker than 1⅛ inches and the outside edge is generally set flush with the outside of the out-

* See, also, Art. 139, Fig. 159, for a few examples of window-frames for brick buildings.

side-casing. In cheap work, also, the rebate in the sill at *R*, Fig. 163, is often omitted. In good work, however, the sill should always be rebated and at least 1⅜ inches thick. A thickness of 1¾ inches is advisable for large windows and in some localities the wooden sills are made 2¼ inches thick. Some architects show, also, the sills projecting to the outer edge of the "staff-bead," *S;* but in the author's opinion there is no advantage in this, except that a narrower stone sill may be used. A wide sill is more apt to "curl up" than a narrow one.

The piece, *S*, is called the "staff-bead" in the Eastern States, and is there usually made with a profile similar to that shown in Fig. 164, although a three-quarter bead is frequently used. Staff-beads are generally worked out of 1⅜-inch stuff. In the Western States this piece is more often called a "brick-mold"; and for dwellings and ordinary brick buildings it is commonly made similar in size and shape to *S* in Fig. 163, 1⅛ inches thick and 2 inches wide. When this shape of the staff-bead or brick-mold is used, the piece, *O C*, is sometimes called the "blind-stop," but more often the "outside casing." A brick-mold with a cross-section similar to that shown in Fig. 163, is best adapted to windows that are fitted with outside blinds.

The distance, *X*, Fig. 163, may be varied to suit the taste of the designer, but is commonly made 2 inches. The distance, *Z*, also, is generally made 2 inches, so that when *X* and *Z* are each 2 inches, the width of the opening for two-light windows is just 8 inches more than the width of the glass. This is very convenient when figuring plans and taking off the length of the sills and caps.

In an 8 or 9-inch brick wall the frame is usually set so that the inner edge of the pulley-stile is flush with the plastering. With 1¾-inch sashes it is generally necessary to clip the backs of the front bricks. In thicker walls the outside casing is generally set in, just the width of a brick and subjambs and casings used, as shown in Fig. 164.

If a 9-inch wall is furred, there is plenty of room for 1¾-inch sashes without clipping the bricks and also for ground-casings, such as are shown on the frame for wooden buildings in Fig. 154.

The piece, *J C*, Fig. 164, is called the "subjamb," or "jamb-casing," the latter term being perhaps the more common. The piece, *C*, is sometimes called the "subcasing," or "inside casing"; but the term "box casing" is considered more appropriate, and is not apt to be confounded with the piece *A*, which also, is called the "casing" in many localities.

The "covering-piece," *V*, is used only where the finish is of hardwood, or is varnished. It has no specific name, but is generally called

a "veneer." The etched portions of the drawings in these figures, with the exception of the sashes and wall, belong to the inside finish. The distance, *Y*, Fig. 164, may be varied from ½ to 3½ inches, but is commonly made about 2½ inches. Under the sill of every box frame there should be built into the wall, a piece of joist to which the wooden sill, the ground, *G*, or the apron, if there is no ground, may be nailed.

The thicknesses of the various parts of a box frame are usually the same as for a skeleton frame, except that in the former the sill is sometimes made thinner, as above noted. For large windows, and for all windows in first-class buildings, the outside casing and the pulley-stile should be 1⅛ inches thick.

Fig. 165 shows sections through the sill and jamb of a window that is quite common in some parts of Pennsylvania, where it is known as a "plank-front" frame. This frame shows a small reveal, and is frequently used without an outside lintel, the outer brick being laid on top of the frame, which is quite heavy. This detail shows, also, a wood sill, which, while not as durable as a stone sill, will last for a long time if kept painted. The detail shows, also, paneled shutters on the outside of the window. These shutters are quite common in old work and were usually made with the panels flush on the outside and molded on the inside. If either shutters or blinds are used on the outside of a window in a brick wall, the hinges should be so shaped that the shutters or blinds will open back "flat" against the face of the wall. Where box frames do not set into the wall, a piece of wood, about 1½ by 2 inches in cross-section, should be nailed to the back lining, as shown at *S*, Fig. 165, to prevent the frame from being pushed in or out.

Fig. 165. Pennsylvania "Plank-Front" Window-Frame.

Fig. 166 shows the details of another typical double-hung window in a masonry wall. The sill is shown at *a*, the jamb or weight-box at *b* and the head at *c*. The outside casings and pulley-stiles are made of ⅞-inch material, although the use of 1⅛-inch material is much better practice. The essential parts of a double-hung window of

this type are the same for both frame and masonry walls. The pulley-stiles and parting-strips should be of hardwood, oiled, but not painted. The construction of the pulley-stile, as here shown, is considered the best and appears just as it is made by the millman. The draughtsman almost invariably indicates it grooved into the outside

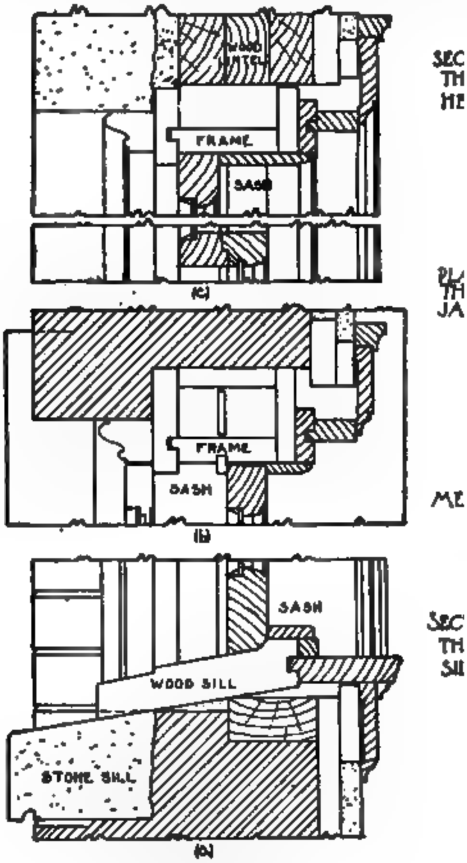


Fig. 166. Typical Double-Hung Window-Frame for Brick Walls. *a.* Sill. *b.* Jamb. *c.* Head.

Fig. 167. Double-Hung Window-Frame in Hollow-Tile Brick-Veneered Wall.

casing, with the tongue on the outside face of the stile. The insertion of a parting-strip, to keep the weights from clashing, is advisable but it is often omitted in cheap work. Though usually hung from the top, it is sometimes housed into the back lining and the pulley-stile.

Fig. 167* shows the details of a double-hung window-frame

* Taken from *Architecture and Building* by permission of the publishers, The W. T. Comstock Company.

in a fire-proof wall constructed of hollow tile faced with brick. Fig. 168 * shows a jamb-section of a double-hung window in a masonry wall. This detail is taken from the University Club building, New York City, designed by McKim, Mead & White. Fig. 169 *† shows various jamb, meeting-rail, mullion, head and sill-details of a special type of double-hung window, designed by Boring & Tilton for the United States Immigrant Station, in New York harbor. Fig. 170 *† shows details of a special type of double-hung window in a masonry wall, designed by Ackerman & Ross for the Port Jervis Public

Fig. 168. Jamb-Section of Double-Hung Window in Masonry Wall. University Club, New York City.

Library, Port Jervis, N. Y. Fig. 171 shows various sectional details of a special type of double-hung window at the side of an entrance-door in a residence designed by Wilson Eyre, Architect, and located at Ardmore, Pa.

Fig. 172 shows the detailed section through the sill, jamb and head of a window-frame for double-hung sashes built in a wall constructed of stucco-covered reinforced salt-glazed tile made by the New York Holding and Construction Company. The drawings show clearly the typical construction and the variations in the details from those used for frames set in brick or masonry walls.

* Figs. 168, 169 and 170 and some others are redrawn, and adapted by permission, from "Building Details," by Frank M. Snyder.

† See, also, Art. 143, "Details of Mullions and Transoms."

Fig. 173 shows how the window-frames at the jamb, head and sill are set into the reinforced-tile walls built according to the system of the New York Holding and Construction Company which makes and controls the patents for the Davis salt-glazed wall,

Fig. 169. Special Type of Double-Hung Window. U. S. Immigrant Station, New York Harbor.

floor and roof-blocks. These details are copied by permission from the drawings for the house designed by Grenville Temple Snelling for Mr. John E. Berwind, at Bridgehampton, N. Y. (See, also, Fig. 172.) At the jambs the back lug of one of the ordinary

wall-tiles is broken out and into the rebate formed in this way, the frame is set. The first cell in the tile back of the frame is poured full of concrete around a reinforcing wire mesh. The same treatment is followed with the spaces between the outer lug of the tile and the outside casing of the window-frame. Across the head of the window in all cases a regular concrete reinforced-lintel is put in place, the reinforcement consisting of two square-twisted Ransom rods. As in this wall-construction the outside stucco is applied directly to the outside surfaces of the wall-tiles and the finished plaster directly to the inside surfaces, without any furring, the

Fig. 170. Special Type of Double-Hung Window. Public Library Building, Port Jervis, N. Y.

grounds are nailed to the window-frames. The joints between the grounds and the plaster are covered by the inside trim, including a small back-band. In this particular house the marble sills have a wide drip cut on the under side. The outside stucco is finished up into this drip so as to prevent any moisture from traveling in a horizontal direction along the under side of the sill and thus getting into the wall.

Fig. 174 shows the detailed sections through the sill and jamb, and Fig. 175 through the head of a window-frame for double-hung sashes built in a stucco-covered wall constructed of the "Natco" *

* Manufactured by the National Fireproofing Company, Pittsburg, Pa.

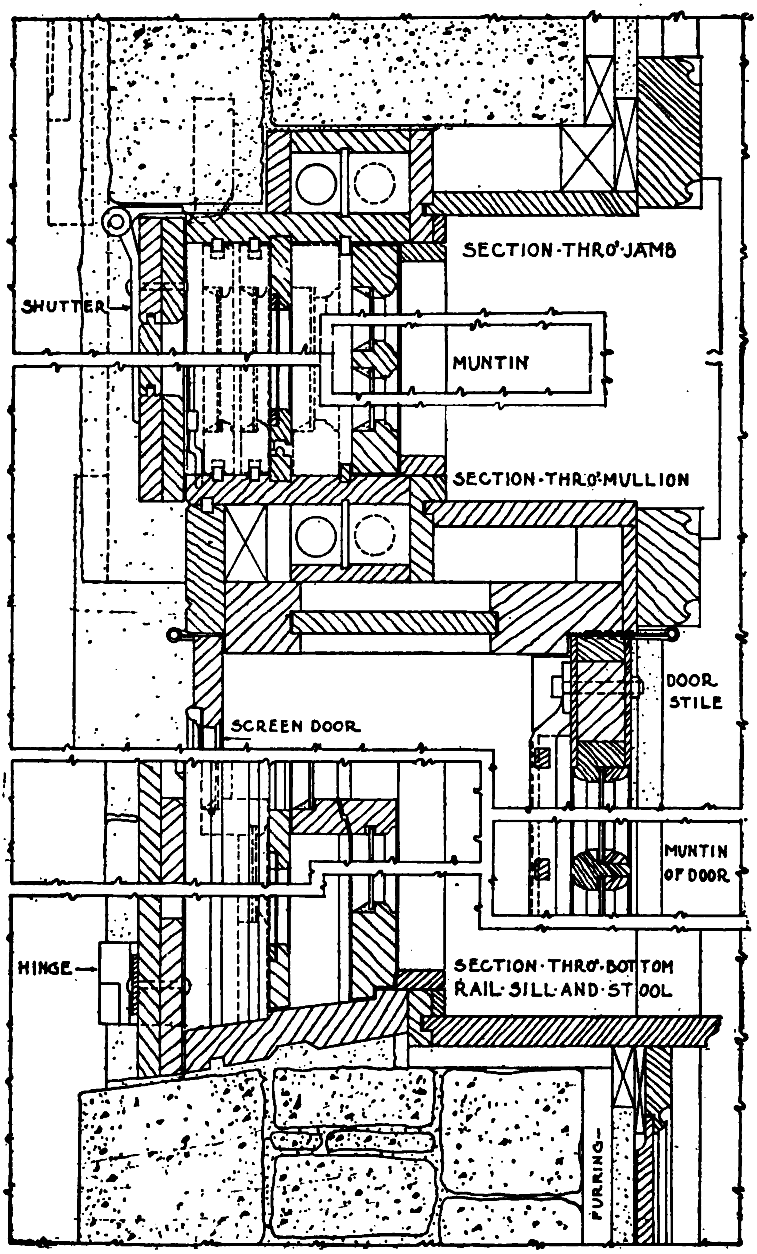


Fig. 171. Special Type of Double-Hung Window at Side of Entrance-Door. Residence, Ardmore, Pa.

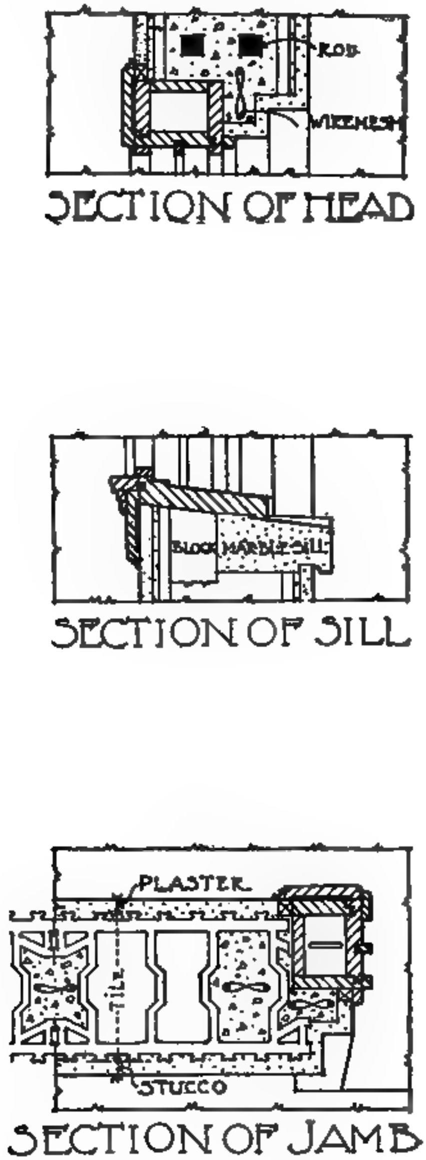


Fig. 172. Window-Frame for Double-Hung Sash in Wall of New York Holding and Construction Co's. Tile.

Fig. 173. Window-Frames, J. E. Berwind House, Bridgehampton, N. Y.

tile. The sections show a specially made tile sill and jamb and also lintel-tiles and clips supported by two steel angles.

142. STORM-RESISTING WINDOWS. Fig. 176 shows various details of storm-resisting windows and double-glazed sashes. Details *a, b, c* and *d* show different forms of double-glazed sashes. Detail *e* shows a good form of sill; and *f* and *g* the sill and jamb of an ordinary storm-resisting window. Detail *h* shows the sill and

Fig. 174. Sill and Jamb-Details of Double-Hung Window in Tile Wall.

Fig. 175. Head of Double-Hung Window in Tile Wall.

jamb of a double set of sliding sashes for use in very exposed positions.

143. DETAILS OF MULLIONS AND TRANSOMS.* Fig. 177 shows the usual method of constructing the mullions and transoms of double-hung frames in wooden buildings, the details given being adapted to the frame shown in Fig. 155. The outside architrave is continued under the sill of the transom, and the molded

* See, also, Figs. 152 (Detail *C, D* and *E*), 169, 170, 178, 179, 181, 182, 183, 184, etc.

part, *M*, may be cut into dentils if desired. The transom-sash is shown over the inner sliding sash, an arrangement which is generally considered the best, if the transom-sash is to open. The best way to open transom-sashes is to hinge them at the bottom to swing in and down, as shown at *H*, Fig. 177, as in this way the joint can be made water-tight. If they are hinged at the top, it is difficult to make the lower joint weather-proof. The groove in the bottom rail of the transom-sash and the rebate in the sill, shown at *R*, are desirable features. Mullions are commonly made like double jambs,

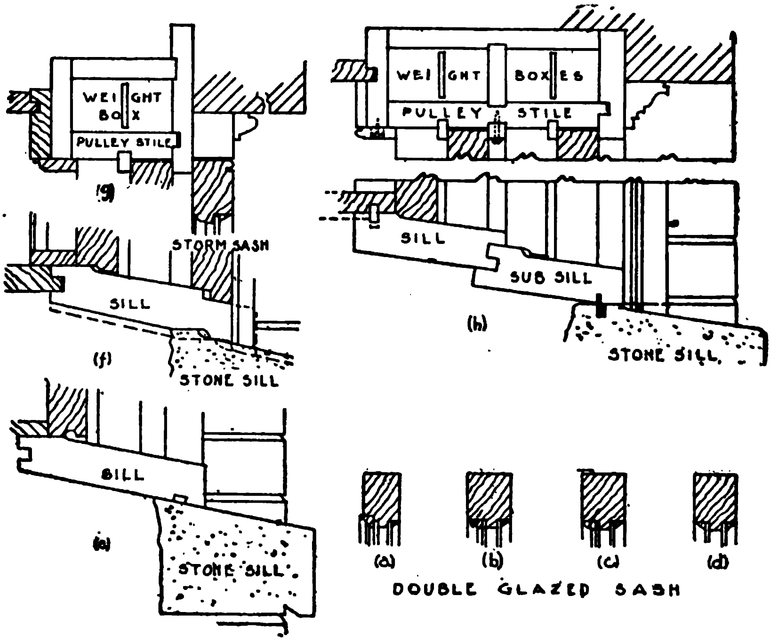


Fig. 176. Storm-Resisting Windows. *a, b, c, d.* Double-Glazed Sash. *e, f, g.* Ordinary Window with Storm-Sash. *h.* Double Set of Sliding Sashes.

with a partition in the middle to separate the weights. For 1¾-inch sashes, hung with round weights, the width of a mullion between outer faces of pulley-stiles should not be less than 7 inches. The partial section at *S* is taken through the pulley-stile above the transom.

Fig. 178 shows sections of box frames adapted to stone transoms and mullions, wooden transoms and mullions in box frames being constructed essentially as shown in Fig. 177.

Where stone or brick mullions are used, a separate frame is required on each side of the mullion; but the stone transom usually projects only through the outside casing, the jambs or boxes extend-

ing the full height of the window. The upper section in Fig. 178 is taken through the side of the frame above the transom. The transom-sash, if stationary, may be put next to the outside casing; but if it is hung at the bottom, the best place for it is on the inside part of the frame, as shown in the figure.

In Fig. 178, a panel set flush with the box-casing veneer is shown for the finish of the mullion, but if preferred, the mullion-boxes may be finished the same as the jambs, with subjambs extending to the face of the plaster. The method shown, however, obstructs the light less and the opening, in general appearance, is one window; while with a boxed mullion it ap-

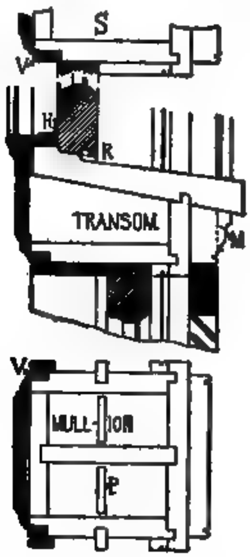


Fig. 177. Mullion and Transom of Double-Hung Window in Frame Building.

Fig. 178. Box Window-Frame with Stone Mullion and Transom.

pears as two or more windows set side by side. When the stone mullion is not as thick as the wall, steel beams should be placed over the window to carry the weight of the wall above. The "reveal" of a window has no effect upon the construction of the frame, but the greater the reveal the less will be the depth of the inside finish.

Fig. 179 shows the various sections through the frames and sashes of one of the dining-room windows of the University Club

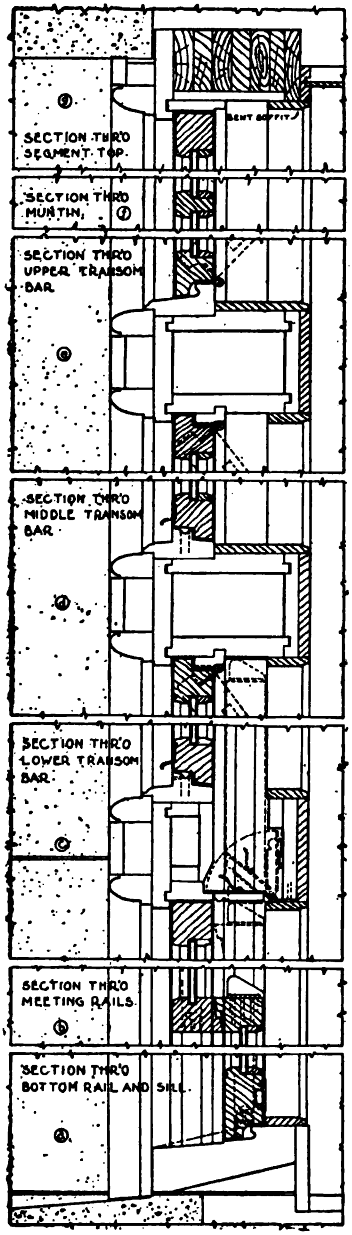


Fig. 179. Dining-Room Window-Frame, Double-Hung and Transom Sash. University Club Building, New York City.

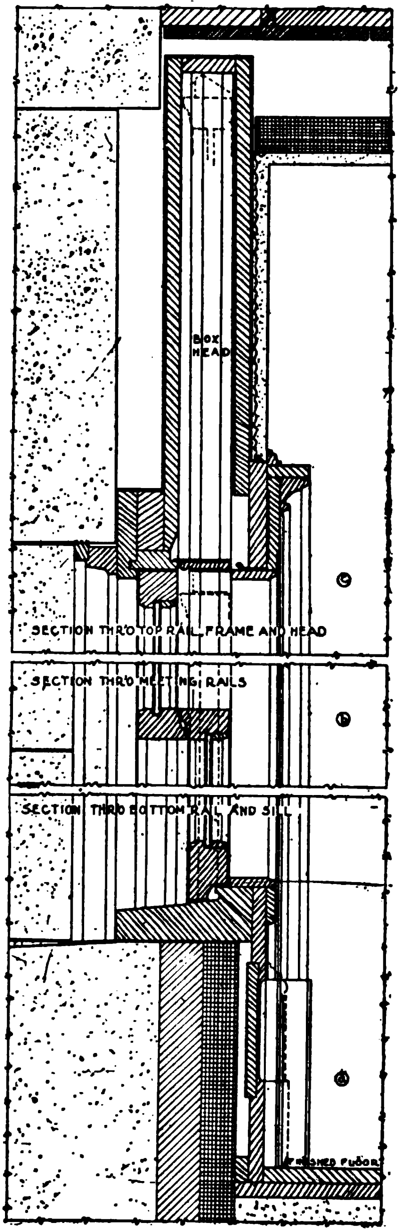


Fig. 180. Window-Frame with Double-Hung Sash and Box Head. University Club Building, New York City.

building in New York City, designed by McKim, Mead & White. The sashes of the lower part of the 18-foot-high window-openings are double-hung and have transoms above, triple-section in height, the two lower sections having the sashes hinged at the top, to swing in and up, and the upper section having a semicircular sash hinged at the bottom, to swing in and down, all as shown in the detail drawings. The lower sash of the double-hung sashes is almost 6 feet in height and slides up past the upper sash, the lower transom-bar and lower transom-sash to the middle transom-bar as shown. The triangular-shaped brass guard for lifting the hinged flap is shown, together with the special hinge to the flap with springs at the back for throwing the flap out of perpendicular when released by the sash coming down. The sash-chains are fastened to the bottom of the double-hung sashes so that they can be detached when the sashes are up. (See, also, Figs. 181 and 182.)

Fig. 180 * shows a vertical section through the bedroom window-frames and sashes of this same club-building. The sashes are double-hung and of unequal height, the lower sash being 4 feet 3½ inches and the upper sash 1 foot 11½ inches high. The lower sash slides up into a box head as shown, the details for hinging the flap at the bottom of the box head and for lifting it being the same as shown in Fig. 179,* although they are not all drawn in this illustration. (See, also, Figs. 181 and 182.)

144. TRANSOM-FRAMES WITH SINGLE LIGHT BELOW THE TRANSOM. *Type E, Fig. 152.* The type of window shown at *E*, Fig. 152, both with and without the mullion, is now frequently used in this country. It differs from the ordinary transom-window in having only one sash below the transom, thereby necessitating an entirely different construction of the frame. Such windows, to be of practical utility, should be constructed so that the lower sash will slide up a distance equal to its height, or nearly so; and the outside of the transom-glass should be accessible for cleaning.

Two quite different methods of construction are shown in Figs. 181 and 182, both of which have the same appearance from the outside. Both frames are constructed with boxes at the sides for weights, as in ordinary box frames, and the lower sash in each is operated exactly as in a double-hung window, except that a pocket is required above the yoke to permit the sash to slide up the full height of the lower opening. This pocket is formed by extending the pulley-stiles and weight-boxes the full height, and covering them on the front and back with matched boarding, the yoke being cut in between the pulley-stiles. Over the opening in the yoke a board,

* Redrawn by permission from "Building Details," Part I. Frank M. Snyder.

S, is fitted, which is pushed up by the sash and drops again as the sash is lowered. This board is called a "follower." (See, also, Figs. 179 and 180.)

In the arrangement of the upper sash, the two details shown differ widely. In the window shown in Fig. 181 the upper sash is con-

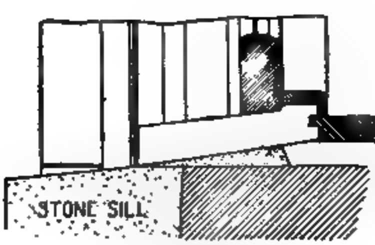


Fig. 181. Single-Light Window with Fixed Transom-Sash and Head-Pocket.

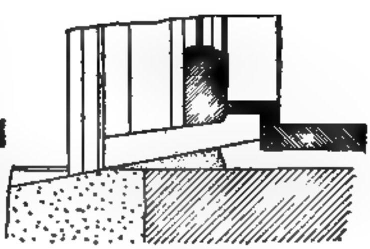


Fig. 182. Single-Light below Transom. Double-Hung Sashes.

structed like any transom-sash, and the inside of the transom is finished by a shallow panel, the panel-molds being cut between the parting-strips. If the lower sash is not more than 4 feet high, and the transom has but a 4-inch reveal, the transom-sash may be stationary, as the glass can be cleaned by standing on the sill and reach-

ing above the transom. If the lower opening is more than 4 feet high, or if the transom has an 8-inch reveal, then the transom-sash should be hinged so that it can be opened; and the best way to do this is to make the outside casing wider, as shown by the dotted lines, and the sash ½ an inch narrower, so that it will swing in by the parting-strips, the sash being hinged at the bottom. In the drawing the transom-sash is shown stationary. The author has used this construction with very satisfactory results.

The construction shown in Fig. 182 is very frequently used, and appears to be a very practical solution of the problem. This construction is the same as that of an ordinary double-hung window with a head-pocket, except that a transom is placed *in front* of the upper sash and the lower portion of the upper sash has a wooden panel. By this arrangement both sashes slide up and down in the usual way and the outside transom is merely for appearance, without the constructive functions of a transom.

The back of the stone transom

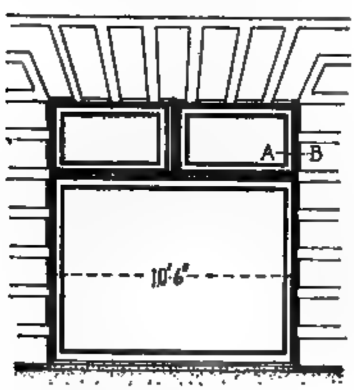


Fig. 183. Large-Light Window in Odd Fellows' Temple, Philadelphia, Pa.

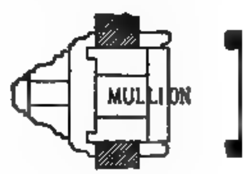


Fig. 184. Sections of Window-Frame Shown in Fig. 183.

covered by a panel, with a space of about $\frac{1}{16}$ of an inch left between the panel and the outer sash. The only objections to this construction are that ice may possibly form between the transom-panel and the upper sash, and that there may be some difficulty in cleaning the glass in the upper sash. When the sash is lowered to reach over it, the bottom of the glass is behind the transom and inaccessible, al-

though it may possibly be reached from below. When the glass must be cleaned from the inside, the construction shown in Fig. 181, with the transom-sash hung, appears to be the best. The dotted lines back of the transom show how a box transom may be built inside; but it is very doubtful if this extra finish adds to the appearance, and it increases the difficulty of cleaning the glass.

Fig. 183 shows the elevation of a window similar to that shown at *E*, Fig. 152, but with the upper lights divided by a wooden mullion. This window is one of several used in the first story of the Odd Fellows' Temple, Philadelphia, Pa., designed several years ago by Hazelhurst & Huckel. The lower light being very wide, permits an extended view from the inside and looks well from outside. The construction of the window is shown in Fig. 184, the lower sash sliding up into a pocket above the head, and the transom-sash being fixed. It will be seen that the general construction is very similar to that shown in Fig. 181, the principal difference being that the transom is constructed entirely of wood and that the parts of the frame are heavier. (See, also, Fig. 207.)

145. PATENT DOUBLE-HUNG WINDOWS WITH REVOLVING SASHES. 1. *General considerations.* Although the ordinary double-hung window has been found superior, on the whole, to any other device for furnishing light and ventilaton, it has two defects, one of which becomes quite serious in the upper stories of buildings. These defects are, that the outside of the glass is not easily cleaned and that only one-half of the opening can be utilized at one time for ventilation, unless a pocket is provided above the head. Several devices have been patented for overcoming these objections. Among the most successful of these appear to be the devices which permit each sash to revolve on a center, thus making it possible to clean the outside of the glass from the inside, and to obtain a greater amount of ventilation in warm weather.

2. *Bolles' Patent Revolving Sash.* Of these patented windows, one which appeared to be the most practicable, or which, at least, found great favor, is known as the "Bolles' Patent Revolving Sash." This window has been very extensively used in New York and neighboring States with very satisfactory results.

The revolving-arrangement can be fitted to any double-hung window-frame, as it affects the sash only. Each sash is pivoted at the center of gravity of the sides, the sash being made narrower than the width between the stop-beads and pivoted to a separate convex strip, which slides up and down in the frame like an ordinary window-sash; and the sash-chains, ribbons or cords are attached to the strips, as shown in Fig. 185. The inner surface of

the strip is convex and accurately fits into a corresponding concave groove in the side of the sash, making a perfectly water-tight joint. The back of the sliding strip is pressed against the pulley-stile by specially designed expansion-pins, fitted with springs; and the pivots, also, are fitted with springs which hold the sash and sliding strip firmly against each other, no matter in what position the sash is placed.

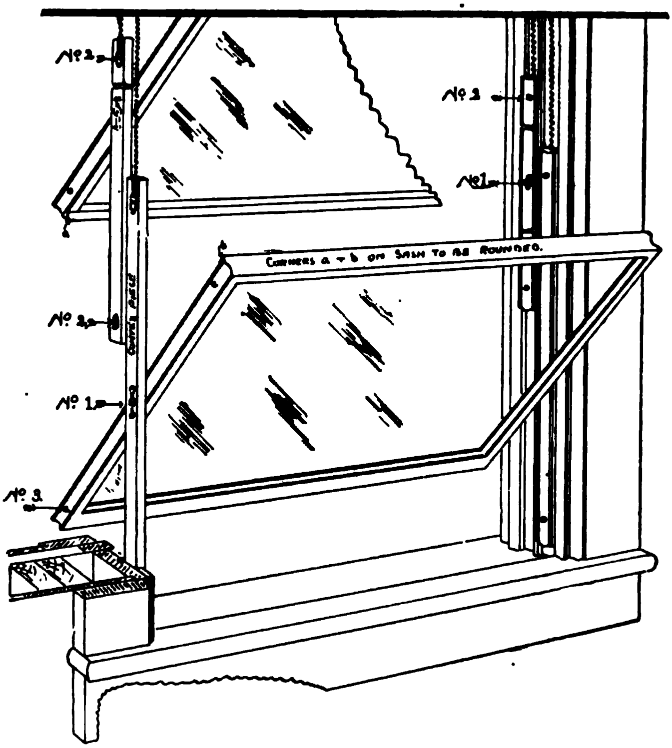
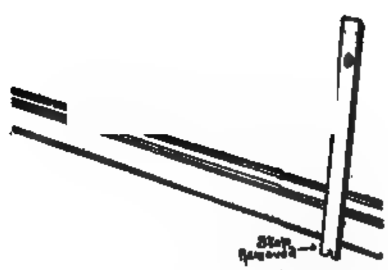


Fig. 185. Bolles' Patent Revolving Sash.

It is claimed that by means of the expansion-pins, above described, the sashes are held as firmly and run as smoothly as in the old-style window and that they are just as tight. In order to turn either sash, it is reversed or placed in a slanting or horizontal position, and all that is then necessary is to push the bottom rail outward, the binding-action of the springs being sufficient to hold the sash in any desired position. The sliding-strips, preferably of straight-grained white pine, may be made at the mill which furnishes the sashes; or they may be obtained from the manufacturers, who furnish, also, all necessary fittings and complete working plans

for shaping the stiles and applying the fittings. The side-pulleys should be placed as high as possible, overhead-pulleys being preferred. The cords and weights are the same as in an ordinary window and the parting-strip projects $^{13}/_{16}$ of an inch. This device is used, also, on transoms and large non-sliding sashes. The mechanism of these sashes and their operation are shown in Fig. 185.

3. *The Bradshaw Reversible Window-Fixture.* Fig. 186 shows



Lower Sash open for cleaning **Upper Sash open for cleaning**

Fig. 186. Bradshaw Reversible Window-Fixture.

the operation of these fixtures. They consist of automatically connecting and disconnecting hinges which are so attached to the window-sash and casing that both the lower and the upper sash may be opened in, as in a swing-door. A button, also, that holds the stop-plate in position, and pulley-clutches that automatically hold the weight-ropes or chains when the sashes are opened for washing, are provided.

These appliances tend to eliminate the dangers of window-wash-

ing by allowing the washer to stand on the floor of the room in a natural position while washing both the inside and outside of the

Fig. 187. Tabor Sash-Fixture. Sashes Closed.

Fig. 188. Tabor Sash-Fixture. Sashes Open.

Fig. 189. Tabor Sash-Fixture and Strip.

Fig. 190. Action of Tabor Sash-Fixture on Double-Hung Sash.

sashes. They may be attached without disfiguring either the sashes or the casings and in such manner that the former will swing either to the right or to the left, but preferably to the left to allow a free

use of the right hand in cleaning. As screens, bars and gratings are in no way interfered with, these fixtures are convenient for schools, jails, hospitals, office-buildings, etc., where the windows are often guarded from the outside. They are made to match the hardware, in two sizes for regular use, and are stamped out of cold-rolled bright steel. Size No. 1 will carry windows weighing up to thirty pounds per sash, No. 2 being used for windows of greater weight. A special fixture is made for use on metal sashes.

4. *The Tabor Sash-Fixture.* This fixture is adapted for use on both double-hung and weightless windows, having either wood or metal-covered frames or sashes, and permits the sashes to slide and revolve. It is weather-proof, the space between the edge of the sash-stile and the pulley-stile being entirely filled by the thicker edge of the hanging-strip. Fig. 187 illustrates the construction, with the sash closed, *a* being the side of the frame, *b* the hanging-strip and *c* the sash-stile. Fig. 188 shows the same parts in position when the sash is open. Fig. 189 is a detail of the fixture and strip. When the strip is drawn to the sash at the pivotal point, this curve forms a spring of the strip itself, at the ends, and a tight and weather-proof joint is assured. The pivot-plates, which are placed between the hanging-strips and sash-stiles, have interlocking corrugations on the contact-faces which hold the sashes at various angles when pivoted for purposes of ventilation; and they take up all wear when the sashes are revolved. The space between the thin edge of the hanging-strip and the pulley-stile allows the strip to swing back with a hinge-motion, unlocking the joint between the strip and the sashes. In this condition the sashes may be adjusted to any desired position. This fixture, like several others of a similar nature, tends to eliminate the dangers of window-cleaning, as the sashes may be placed in any required position, turned entirely around, or removed at will by the operator while standing on the floor. Another fixture is made, also, for use with windows having fixed screens or outside gratings, as in prisons, banks, etc. In this case the sashes, when closed, are locked to the strips by specially designed catches which cannot be tampered with, as they are out of sight and operated by a key. Fig. 190 illustrates the action of the regular fixture when used with a double-hung window. This fixture can be used when two or more sashes are placed one outside of the other; and by a simple equalizing-connection each inside sash operates the one next outside, both in opening and closing. These fixtures are adapted for use on all types of buildings.

146. CASEMENT-FRAMES. Windows in which the sashes are hinged at the sides, to swing in or out like a door, are called

"casement-windows." When the windows are 6 or 7 feet high and the sashes are divided into two folds, the sill coming nearly to the floor, they are frequently termed "French windows."

It is very difficult, and in fact almost impossible, to construct a casement-window so that the rain cannot beat in, unless the sashes are hung to swing out; and if the sashes open outward it is impracticable to use outside fly-screens. If the window is in an ex-

Fig. 191. Section of Casement - Window, Sashes Swinging Out.

Fig. 192. Section of Casement - Window, English Method, Sashes Swinging In.

posed position it is much better to hang the sashes to swing out, even if this does necessitate inside-screens.

The construction of a casement-window frame is very much like that of a door-frame, the difference being in the arrangement of the wood sill and in the rebate for the sashes.

Fig. 191 is a section through the jamb, sill and meeting-stiles of a casement-window in which the sashes are to swing out, showing the English method of forming the rebates. In ordinary work in this country, the half-round rebate, *B*, and also the astragal-mold at *A*, are generally omitted, the meeting-stiles having an ordinary

rebate. Fig. 193 shows a style of casement-frame often used in the East. The rebate for the bottom of the sashes is the same as in the previous example, but the side-rebates are different. The hollow in the edge of the stop-bead is made with the idea that if rain is driven through the rebates it will stop in this space and descend to the sill, where an outlet should be provided for it. With a frame of this pattern the sashes can swing open only a little more than 90 degrees. If it is desired to swing the sashes back against the walls, the edge of the frame must be kept out nearly flush with the face of the wall. The strip of board shown on the back of the frame is nailed to it for the purpose of holding it more securely in place, and it may be put on in short

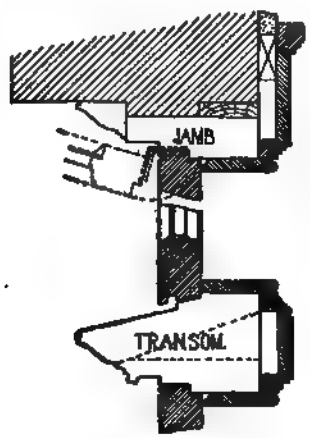


Fig. 193. Casement-Frame. Eastern Method.

Fig. 194. Casement Window-Frame. Sash Opening In.

lengths. The shape of the staff-bead is a matter of design; it is often "stuck" on the frame, but there are some advantages in making it a separate piece, as shown in the figure. The dotted lines across the transom-bar show how it may be built of two pieces of plank.

Figs. 192 and 194 show two details for casement-frames with sashes opening in. The former shows the English method of construction, which is generally considered the best, although the sill-detail shown in Fig. 194 is an excellent one This joint is designed with the idea that if water penetrates to the groove, *G*, Fig. 194, the driving force will be diminished by the increased area of the space, and that the water will collect in the bottom of the groove and pass out through little holes bored through the outer lip.

The outside-finish of the frame shown in Fig. 194 is merely

offered as a suggestion, as it is not an essential part of the construction, the most important constructive features of these two details being the connections between the jambs and sill. Casement-window frames and sashes should be at least 1¾ inches thick and when in brick or stone walls should be well secured to the masonry.

When casement-windows are less than 5 feet high, and more than 3 feet wide, it is better construction to have a narrow mullion between the sashes than to have the sashes rebated together.

Fig. 195 shows various jamb and sill-details of casement-windows opening in. Details *a, b* and *c* are for frame walls and *d, e* and *f* for masonry walls. Detail *d* illustrates an elaborate form of

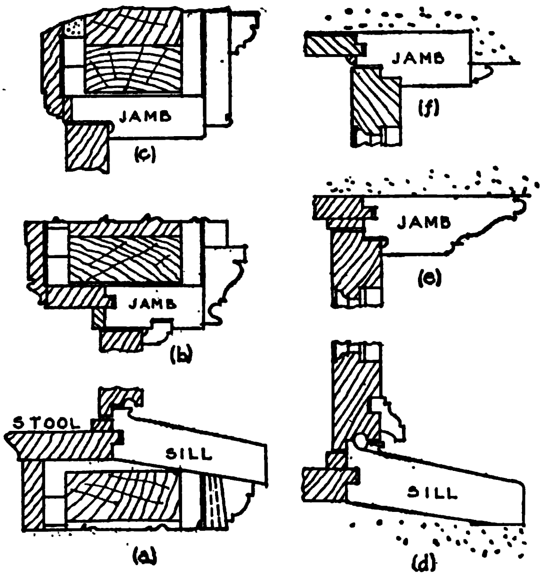


Fig. 195. Casement-Windows, Sash Opening In.
a and *d*, Sills; *b, c, e* and *f*, Jambs.

sill-construction which has been carefully studied to make it as weather-proof as possible. Fig. 196 shows a variety of jambs, transoms and meeting-stiles for casement-windows opening out. Sections *a, c, i* and *m* are of meeting-stiles, *i* requiring both leaves of the window to be opened or closed at the same time. Fig. 197 shows the details of a casement-window in a masonry wall opening out and having mullions and transoms. In this type the woodwork is reduced to a minimum in order to secure as large a glass-area as possible. With metal frames and sashes the glass-area can be still further increased. Stone mullions and transoms are usually made from 4½ to 6 inches in thickness in windows of this charac-

ter. Fig. 198* shows various details of a large window, 20 feet in height, in the Home Club building, New York City, designed by Gordon, Tracy & Swartwout. The drawings show sections through the curved transom-sash, muntins, rail at top of swing-sash and

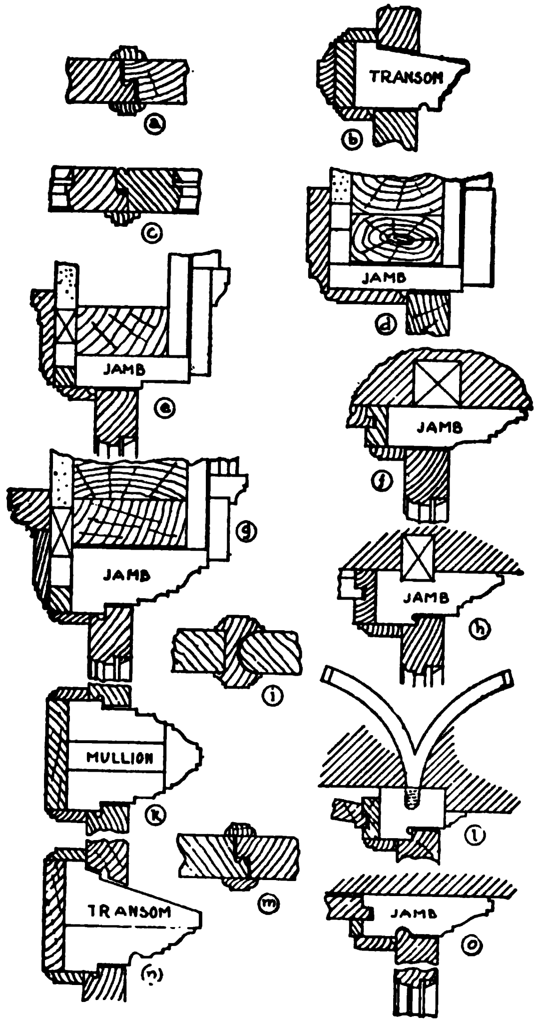


Fig. 196. Casement-Windows, Sashes Opening Out.

bottom rail and sill. A lower section of the whole window is arranged as a casement-door, swinging out onto a balcony. Fig.

* Fig. 198 and several others are adapted, redrawn and used by permission, from "Building Details," by Frank M. Snyder.

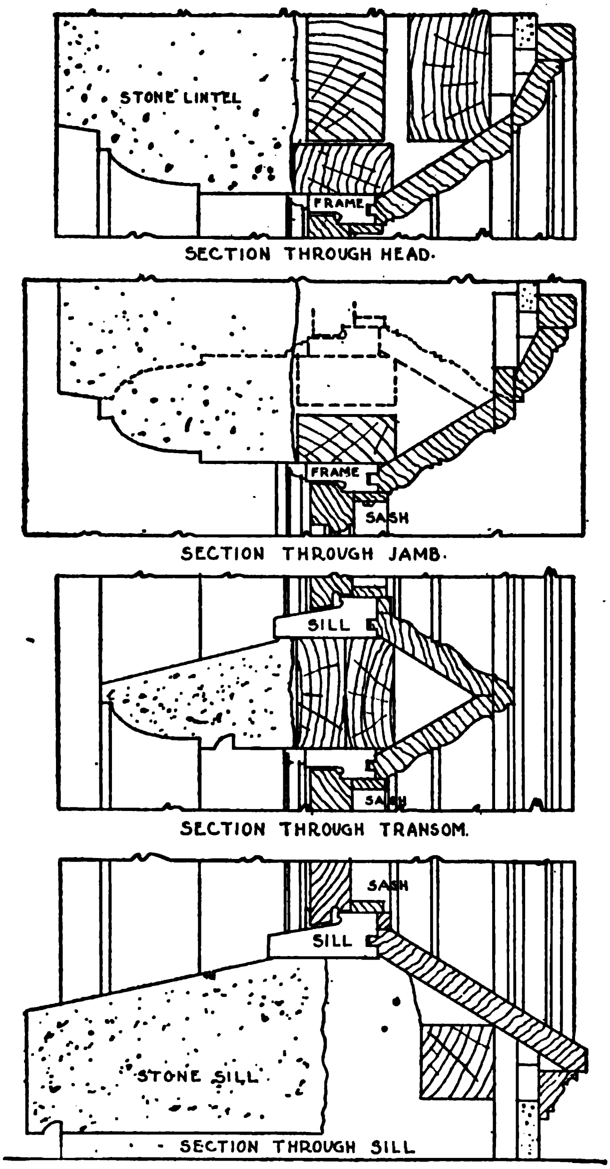


Fig. 197. Casement-Window in Masonry Wall, Sashes Opening Out.

199 shows the details of an inexpensive and practical casement-window with sashes made to swing out and designed for frame walls. This was designed by Willatzen & Byrne, of Seattle, Washington. The "shiplap" siding and exterior trim are "rough-from-the-saw." Fig. 200 shows jamb and sill-details for a double-sash casement-window for very exposed positions, the outer casement opening outward and the inner opening inward. All the finish inside of the outer sashes should correspond to the inside finish of the room in order that the inner sashes may be removed in summer. If required, mosquito-screens can be substituted for them.

Fig. 201 shows various details of casement-windows constructed to secure weather-tight joints. The large-scale section is through the jamb and meeting-stiles of an ordinary casement-window frame.

Fig. 202 * shows various detail sections through the frames, sashes, paneling, etc., of the casement-doors and casement-windows of the building designed by H. Van Buren Magonigle for Mrs. Daw's School, at Briercliff Manor, New York. Sections *a, b, c, d, e* and *i* show the construction of the casement-doors and sections *f, g, h, k* and *l* show the construction of the casement-windows.

Metal casement-windows were used in the time of the Roman Empire, but faults in their construction, mainly those of leakage,

Fig. 198. Transom and Casement-Sashes of Large Window.

*Redrawn and used by permission, from "Building Details," Part I, by Frank M. Snyder.

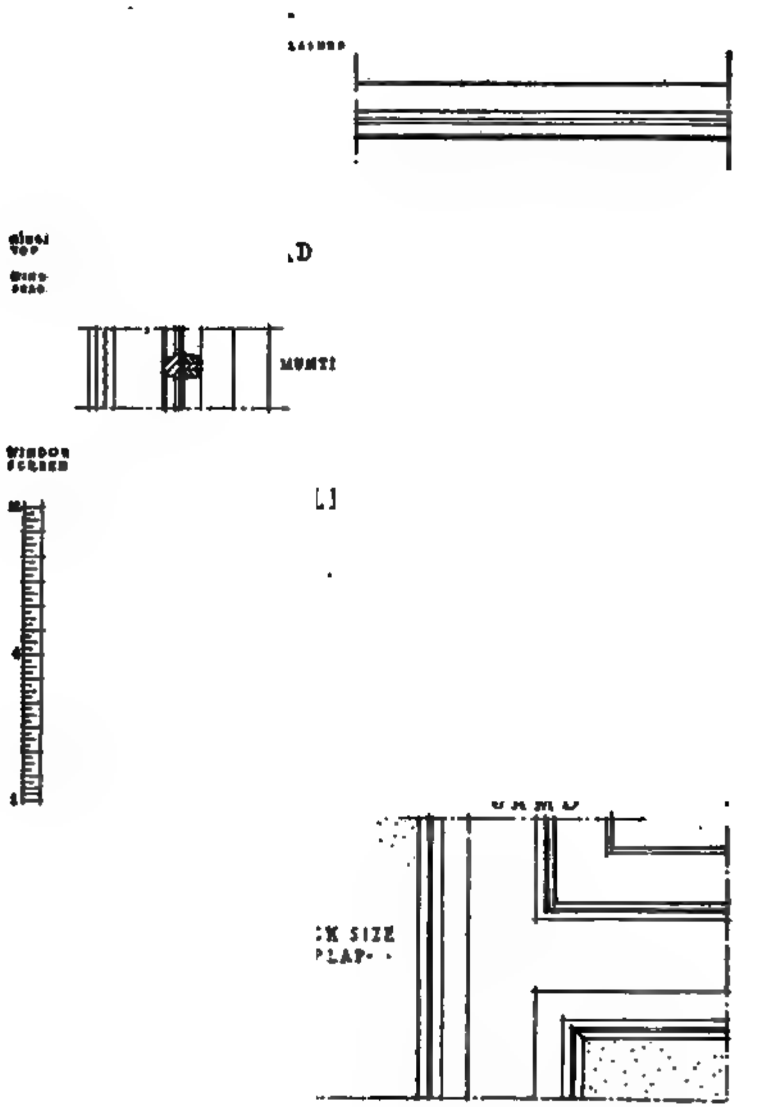


Fig. 199. Casement-Window in Frame Wall, Sashes Opening Out.

gradually led to the substitution of wood for metal. Within the last twenty-five years metal casements have been so much improved that up to about 30 square feet in area for each opening-leaf they are now practical for modern use.

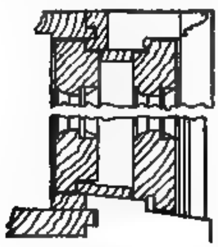


Fig. 200. Double-Sash Casement-Window for Exposed Positions.

The ideal casement-window should be permanent, rust-proof, fire-proof and weather-tight. Provision should be made for condensation and for opening to the full width. It should not rattle, warp or twist and should open and close easily, offering a minimum obstruction to light.

The "Economic"* metal casement is not meant to supersede the ordinary casement and frame, both of which, in masonry buildings, are usually made of metal; but to furnish a window which has the appearance of an ordinary all-metal casement without the disadvantages of a wooden one and which is weather-tight under all conditions. It is designed for use in wood openings only, consists of a metal-casement frame hung on wood jambs and is in contact with metal strips all around. These casements are made of solid bronze, "koperoid-steel" and solid steel

Fig. 201. Casement-Window Details for Weather-Tight Joints.

in rolled, patented, welded sections. Fig. 203 shows a section of the lower rail of a metal casement used in a masonry wall. The bronze condensation-gutter, also, is shown in this figure. Fig. 204 shows the jamb-detail for a similar window and Fig. 205 the section

* Manufactured by the Crittall Casement Company, Detroit, Mich.

Fig. 202. Casement-Doors, Sashes and Frames, Mrs. Dow's School-Building, Briarcliff Manor, New York.

and details of the "Economic" metal casement for use in wood jambs. The molded metal strips which are fixed to the woodwork by ordinary wood screws overcome any unevenness in the wood framing, while the double strip at the sill collects and drains the water of condensation. All openings for this type of window should be made with $\frac{3}{8}$-inch rebates all around.

147. PIVOTED SASHES. *Sashes Pivoted at the Sides.* In many places where windows with single sashes are used it will be found better and more economical to pivot them at the center of the sides than to hang them on hinges. In audience-rooms, especially, this is a very good arrangement for small windows, and sashes as high as 8 and 10 feet are often pivoted in this way. By swinging the sash out at the bottom and in at the top, the danger from leakage is not much greater than in a double-hung window.

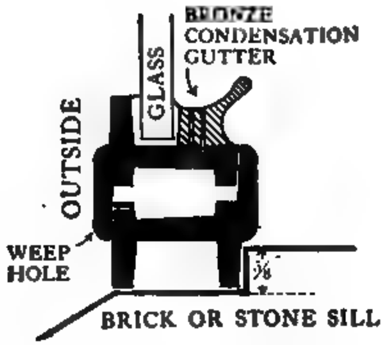


Fig. 203. Lower Rail of Metal Casement-Window in Masonry Wall.

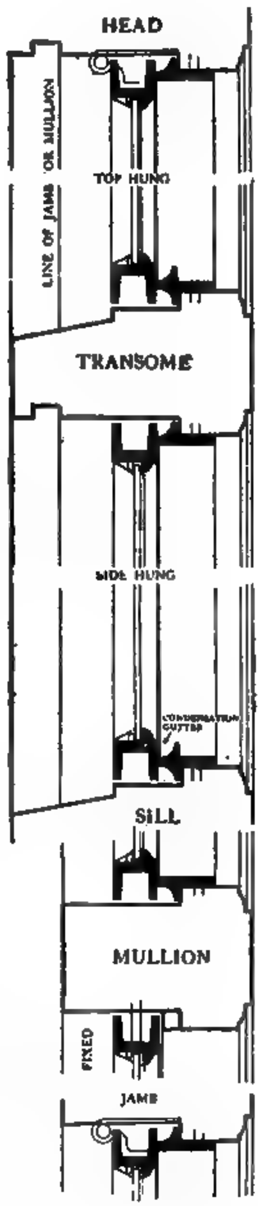


Fig. 205. Details of "Economic" Metal Casement-Window.

The frames for such windows should always be made of planks; and they should not be rebated, but made as shown in Fig. 206, with stops, *S S*, nailed partly to the frame and partly to the sash, as shown. Both stops are cut on a bevel near the center of the window, the upper part of the outside stops being nailed to the frame and the lower part to the sash, while the reverse is the case with the inner stop. The sill-joint should be as shown in Fig. 191.

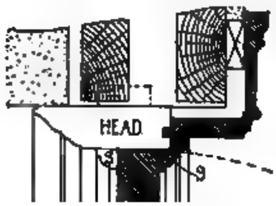
2. *Sashes Pivoted at the Top and Bottom.* Large plate-glass windows, with single lights, are generally pivoted at the top and bottom; and when the sash is unsymmetrical in shape, as in the case of the outer sash in the window shown at *I*, Fig. 152, this is about the only practical method of opening the window.

The frames of such windows should be made of planks, and the joint between the bottom rail of the sash and the wood sill

Fig. 204. Jamb of Metal Casement-Window.

should be arranged in a manner similar to that shown for casement-sashes which open it.

Fig. 207 shows the detail of the large single-light windows in the



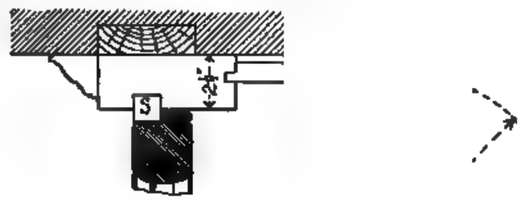


Fig. 206. Window-Sash Pivoted at Sides. Fig. 207. Window-Sash Pivoted at Top and Bottom.

Odd Fellows' Temple, Philadedphia; and the manner of stopping the sash at the sides appears to be about as good as can be devised. The stop, *S*, is placed flush with the outside of the sash at one side of the window and flush with the inside of the sash at the other side, as shown in the plan. Such windows are constructed also in a manner similar to that shown in Fig. 206, with one stop nailed to the inside of the sash and the other to the outside and with the upper stops cut at the center. Windows, up to 5 or 6 feet in width, may be pivoted in this way, but the sash should be made quite heavy and never less than 2¼ inches thick. (See, also, Figs. 183 and 184.)

Fig. 208. Angle of Bay Window in Masonry Wall.

148. BAY WINDOWS. 1. *General Construction.* As bay windows are commonly constructed there is a solid pier at the angles, and the windows proper are made in the same way as if they were in a straight wall. When the bay is of masonry and it is desired to have the angle between the windows as small as possible,

iron or stone angles or mullions are used. Very frequently an iron post is set in the angle to support the lintels above and cased on the outside with stone or terra-cotta. Fig. 208 shows a section through an angle constructed in this way. The detail may be of value to the younger architects as it shows the manner of securing the frames and the terra-cotta casing.

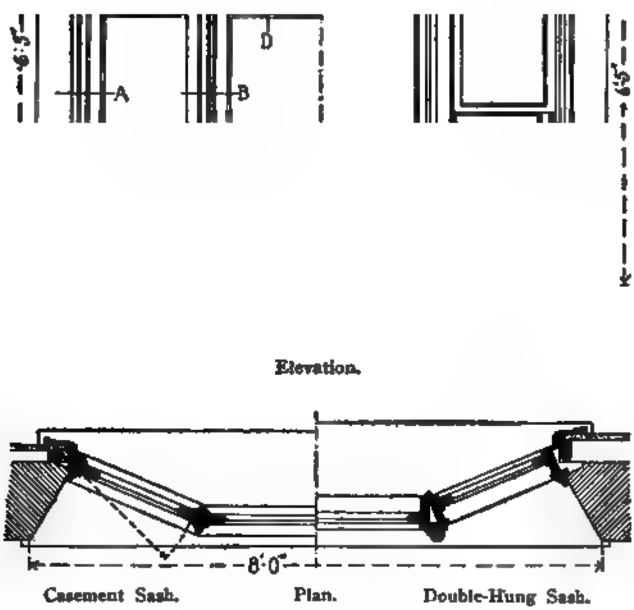


Fig. 209. Shallow Bay Window.

2. *Shallow Bay Windows.* Bay windows of this type are often built within the thickness of the walls of brick or stone buildings; and in such cases the whole bay is formed by the window proper. Fig. 209 shows a half-elevation and plan of two styles of such windows. In the one at the left, a casement-sash is used and in the one at the right the side-window is double-hung, while the

center sash is stationary or pivoted at the top and bottom. Enlarged sections, on the lines *A*, *B*, *C*, etc., are shown in Fig. 210. In such windows the woodwork should be as light as practicable and hence the pockets for the weights are dispensed with in the double-hung window and sash-balances used instead. By making the angle about 3 inches wider, however, pockets can be used.

The lead strip shown in Section *E*, Fig. 210, is suggested as a good detail to protect from the weather the joint under the wood sill of any window; and, although not often used, is an approved construction for all first-class residences. The inside finish of the head and sill would be essentially the same in both of the windows shown. When such windows extend through two stories the wall under the upper windows need not be more than 6 inches thick, thus increasing the size of the room.

Fig. 210. Details of Bay Window Shown in Fig. 209.

Stone lintels over such windows should either be as thick as the wall or they should be supported by iron lintels, each with a wide plate at the bottom flush with the stone.

149. ORIEL WINDOWS. Fig. 211 * shows various sections through a side-gable and oriel window in the residence designed by Aymar Embury, II, for Mr. Daniel Pomeroy at Englewood, N. J. Sections *a* and *b* are taken through the string-course moldings between the first and second stories. Section *b* shows also the sill and lower part of the casement-sash. Section *c* is taken horizontally through the jambs of the casement-windows. Section *d* is taken

* Figs. 211 and 212 are adapted, redrawn, and used by permission, from "Building Details," by Frank M. Snyder.

vertically through the head of the casement window-frame and through the eaves of the oriel roof. The exterior plaster-work was put on in two coats on expanded-metal lath which was painted two coats and laid on top of the sheathing paper on $\frac{5}{8}$ by $1\frac{1}{2}$-inch strips set not over 12 inches on centers. The studs are of hemlock and the exterior woodwork, except the shingles, entrance-door, window-frames and sashes, is of chestnut, stained a dark-brown color. The shingles are red cedar and the window-frames, sashes and trim are white pine, painted white. All upper surfaces of projecting moldings, etc., are flashed with tin, as shown.

Fig. 211. Oriel-Window Framing, Residence, Englewood, N. J.

Fig. 212 shows the details of an oriel-bay window in the dining-room of the house referred to in the preceding paragraph. The drawings include a small section of the entire oriel bay with the zinc-lined flower-tray, strainer and drain; a larger section through corner, sill and bottom of oriel bay; sections through oriel cornice and through the oriel where it joins the outside walls of the building; and a vertical section through the dining-room wainscoting and ceiling-angle moldings. The sashes swing out and are trimmed with bronze sash-adjusters at the bottom and bronze lever sash-fasteners near the centers. The interior wood finish is of cypress, stained a dark-brown color, the interior plaster has a buff-painted sand-finish and the floors are ash. The various details of construction are clearly shown.

Fig. 212. Details of Bay Window with Flower-Tank, Residence, Englewood, N. J.

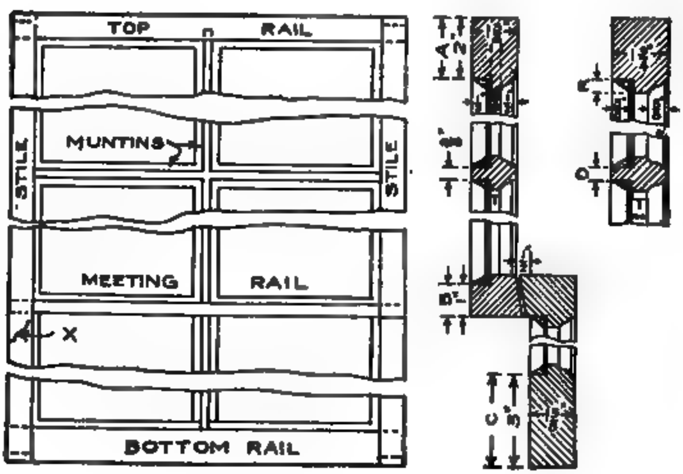


Fig. 213. Window-Sash Details.

3. SASHES.

150. DETAILS OF SASH-CONSTRUCTION. The movable frames which receive the glass in any style of windows are called "sashes," and are made for various types of windows in essentially the same manner throughout the country. Fig. 213 shows an elevation of the sashes for a double-hung window and enlarged sections through the rails.

The pieces forming the top and bottom of the sashes are called "rails," and the side-pieces "stiles." The small bars dividing a sash into lights are usually called "muntins," although sometimes they are called "sash-bars." The latter term, however, is more frequently applied to the bars which divide the large windows used in store-fronts. The different pieces of glass are commonly called "lights," and a window is spoken of as "one-light," "two-light," "four-light," etc., according to the number of "panes" of glass in the *whole* window. Formerly, windows of ordinary size were made with as many as eight and twelve lights, owing to the greater cost of large pieces of glass; but now such windows are generally made with only one light in each sash, and are called "two-light windows" when double-hung. The sashes in factory-windows, etc., are still made with eight, twelve or eighteen lights, and in dwellings small lights are sometimes used for architectural effect. Glass is now so cheap, however, and it is so much easier to clean windows having but one light to each sash, that large lights are greatly preferred.

As a rule, the size of a window is indicated by the size of the glass and the number of lights. Nearly all lumber-dealers carry several sizes of sashes in stock, ready-glazed, and such sashes are called "stock sashes." They cost a little less than sashes which are made from special designs and are generally used in the cheaper class of buildings.

The common thicknesses of sashes are 1⅜ and 1¾ inches, but the thinner sashes should be used only in the cheapest class of buildings. The usual proportions of the rails and stiles in such sashes are indicated in Fig. 213. In New England the width *A* is generally only 1¾ and the width *C* 2¼ inches; but in the Middle and Western States the dimensions given are almost universal.

In stock windows and in specially designed windows, unless otherwise indicated, the width, *B*, of the meeting-rail is made 1 inch. In wide windows these rails are quite sure to spring and should therefore either be made heavier or be made of oak. The cross-sections of the stiles and top rails are always made the same.

Two details are shown for the meeting-rail of the lower sash. Both appear to be commonly used, even in stock sashes. In the 1⅜-

inch sash the lower meeting-rail is shown rebated for the glass and in the 1¾-inch sash it is grooved to receive the glass. There is more wood in the former section and hence it is the stiffer of the two, but of course it offers greater obstruction to the vision. Occasionally the joint between the meeting-rails is lapped, as shown by the dotted lines on the section of the 1¾-inch sash; but this is not as desirable a joint as one with a straight bevel.

In all kinds of sashes the rails are mortised and tenoned into the stiles, the thickness of the tenon being usually the width of the fillet *T*, shown in the sections, Fig. 213. In sashes thicker than those shown it should be about one-third the thickness of the sash. The shape of the molding on the inside of a sash may be varied to suit the individual taste, but it should be such that it will permit of "coping" to advantage at the joints, the forms of the moldings shown being about the best for this purpose.

The weakest parts of a double-hung sash are the meeting-rails and the parts tenoned to the stiles. The tenon is not infrequently pulled out of the mortise in raising or lowering the sashes. To avoid this the stiles are sometimes extended below and above the meeting-rails, as shown at *X*, in the elevation-drawing, Fig. 213. This makes a strong joint and is recommended for offices, tenements, etc. Such an extension, of course, prevents a sash from being raised or lowered its entire height, but in large windows this is of no great consequence.

Sashes for plate or leaded glass should never be less than 1¾ inches thick and 2¼ inches gives better results. For very large windows, 2¾-inch sashes are sometimes used.

Single and double-strength glass is generally secured by zinc "glaziers' points" and putty. Plate glass is generally secured by a wooden strip, as shown in Fig. 184.

Wooden sashes should be made from the best quality of white pine, Douglas fir, cypress or redwood, clear, straight-grained white pine being generally preferred. Hardwood sashes are sometimes used, but they are more likely to warp than pine sashes. Where a hardwood finish has been desired, veneered white-pine sashes have sometimes been used. (See, also, Art. 154.)

151. STOCK WINDOW-SASHES. Nearly all lumber-dealers carry in stock certain sizes of sashes which are commonly known as "stock sashes"; and the two sashes for a double-hung window form a "stock window." As these stock sashes or stock windows are made in great quantities, they can be sold at a relatively lower price than is asked for sashes which are made to order; and hence they are extensively used in the construction of the cheaper class of buildings, especially in smaller cities and towns.

other lights about 3 or 4 feet in height above them. In such store-fronts framed sashes are not used, but instead, small posts or sash-bars, extending from the sill to the top of the window, are set up between the lights, and other similar bars are cut in between them at the height of the lower light, thus making a framework to hold the glass.

As the desire of the ordinary merchant is to have as much plate glass as possible, the columns which support the wall above are usually set 4 or more inches inside of the wall-line, and the plate glass not more than 1½ inches inside of this line, and sometimes flush with it, in order that the window may be placed in front of the columns and extend unbroken, except by the entrances, from corner to corner.

It is the custom also to make the bars separating the lights of glass of the least size that will give sufficient strength to hold the glass and prevent the window from being blown in. In the better class of stores the outside of the sash-bars is usually covered with ornamental metal, and very often iron bars are placed in the woodwork to give the necessary strength and to prevent warping.

Fig. 214 shows types of sash-bars formerly in common use in large windows, although they were varied in size and in the detail of the moldings. Sections *A, B, D, E* and *F* are drawn to one-fourth full size.

Sections *A* and *B* were quite common in Chicago. The strength of the bar is afforded by a cast-iron T, of which only the front was exposed. The front was generally copper-plated and oxidized and often ornamented by relief-work. The T was filled out to a square by pieces of thoroughly seasoned wood, screwed or bolted together as shown. Wooden stops were then screwed to the wood core to hold the glass, or iron stops were used if preferred; but hardwood was considered better. The usual size of sash-bars of this pattern was 3 inches in width by 2½ inches in depth, exclusive of the inside casing and stops, but they could be reduced to 2½ inches in width and made 3 inches in depth. The section at *B* is for an angle in the window. When the angle is a right angle the cast web is omitted and the facing is screwed to a solid piece of wood.

Sections *E* and *F* have been extensively used in all large cities and as a rule have been found cheaper than the cast-iron bars. In these bars the whole construction is of wood, which should be of the best quality white pine or cypress, the glass being held by a half-round strip screwed to the bar. The half-round is covered on the outside with thin brass or copper, which may be nickel-plated or oxidized, the metal extending about ¼ of an inch over the edge to hold it in place. Such bars look as if these were made of solid metal. They are carried in stock in sizes of 2, 2½ and 3 inches, or can be made to order. They can also be adapted to any angle in the manner shown at *F*.

The wooden bar forming the support is, of course, made by the carpenter and should be about 2 by 3¾ inches. It may be plain or molded, as desired.

Sometimes a wrought-iron bar, about ⅝ of an inch by 3 inches, was placed in the center of the wood-bar, corresponding to the web of the T, detail *A*, Fig. 214, and the metal-covered bar was screwed into the edge of the iron bar, as shown by the dotted lines at *E*. This added much to the expense and

does not appear to have been necessary if the wooden bars were made of the size above indicated.

The cross-bars were generally made of the same section as the upright bars, although this was not necessary.

The detail at *D* shows a wooden transom-bar which has been used with very good effect in connection with the upright bar *E*.

Whatever may be the shape of the bars, the upright bars should always extend in one length, from sill to head, and the horizontal bars should be cut in between them.

With bars of the shape shown at *D, E* and *F*, it is of course necessary to set the glass from the outside. It is generally considered best that all

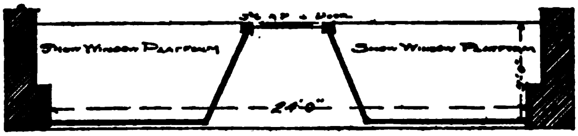


Fig. 215. Plan of Store-Front.

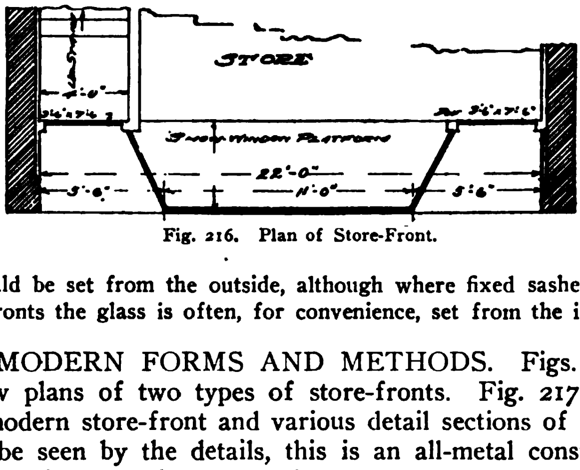


Fig. 216. Plan of Store-Front.

glass should be set from the outside, although where fixed sashes are used in store-fronts the glass is often, for convenience, set from the inside.

153. MODERN FORMS AND METHODS. Figs. 215 and 216 show plans of two types of store-fronts. Fig. 217 shows a typical modern store-front and various detail sections of the same. As will be seen by the details, this is an all-metal construction * reinforced with No. 16-gauge steel.

Fig. 218 illustrates another form of store-front construction,† a wood core reinforced with T irons and angle-irons being used in this case. As shown in the cut, the metal covering and the reinforcement-irons are secured to the wood core by screws. An enlarged detail, also, of the drainage-sill used with this construction is shown. This takes care of the water of condensation or the moisture occasioned by cleaning the inside of the window. The moisture runs down into the gutter on the inside and is carried out

* Manufactured by The Perfection Metal Bar Company, Cleveland, O.

† Manufactured by J. W. Coulson & Company, Columbus, O.

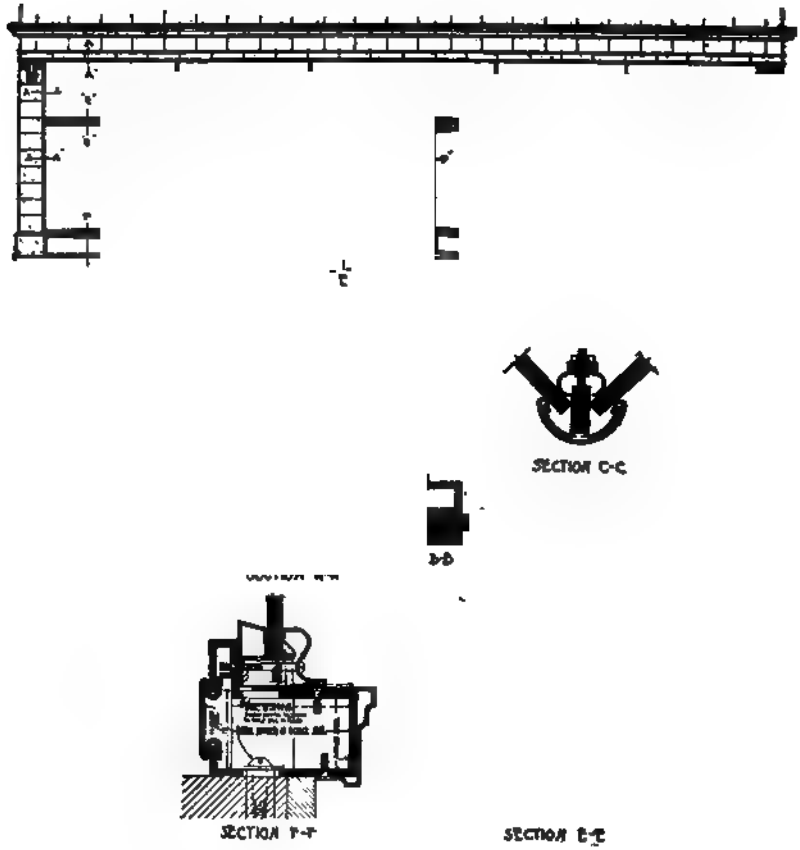


Fig. 217. "Perfection" Store-Front Construction.

through the metal tubes which are placed at intervals as shown in the illustration.

Figs. 219 and 220 show an all-cast-iron type of store-front construction.* In Fig. 219, section *H H* shows the typical vertical

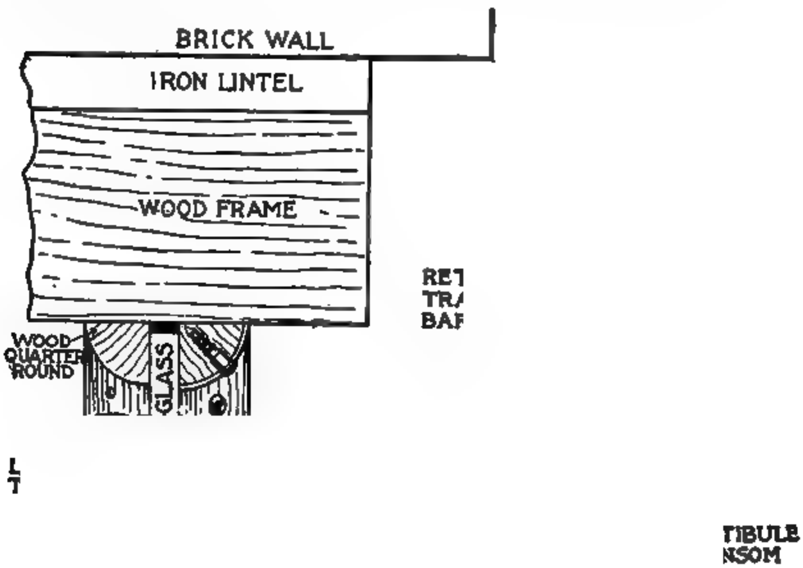


Fig. 218 Details of Coulson Store-Front Construction.

section, *A A* being the head and *J J*, *K K*, and *L L*, Fig. 220, being variations of the construction below the sill. *L L* shows a solid wall below window. Section *I I* shows the transom and the attachment

* Manufactured by Love Bros., Inc., Aurora, Ill.

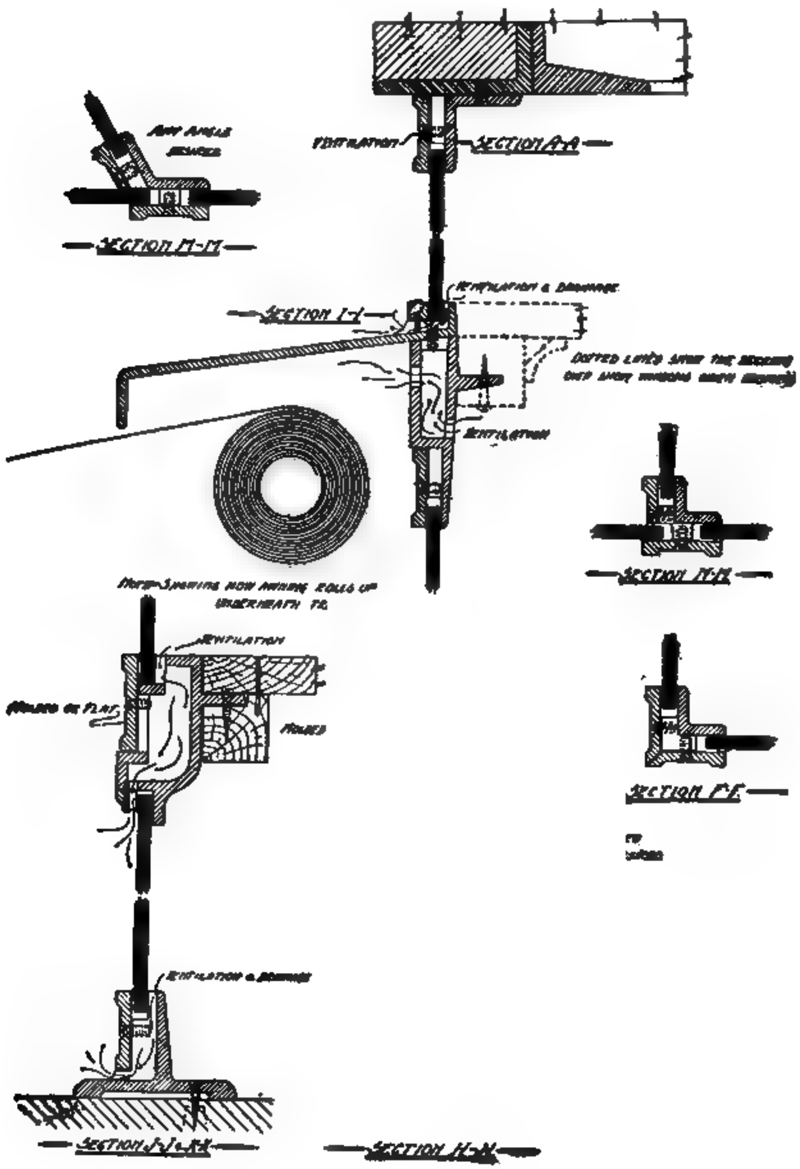


Fig. 219. Cast-Iron Store-Front Construction. Love Brothers, Inc.

for protecting the awning when rolled up. Sections *F F* and *M M* (Fig. 219) and *B B* and *G G* (Fig. 220) are various details of corner and division-bars. Sections *A A* and *D D* (Fig. 220) show the plans from the jambs at the outer edge of the window and at the door.

Fig. 221 * illustrates the sill, transom and head of another type of all-metal store-front construction. The heavy black members

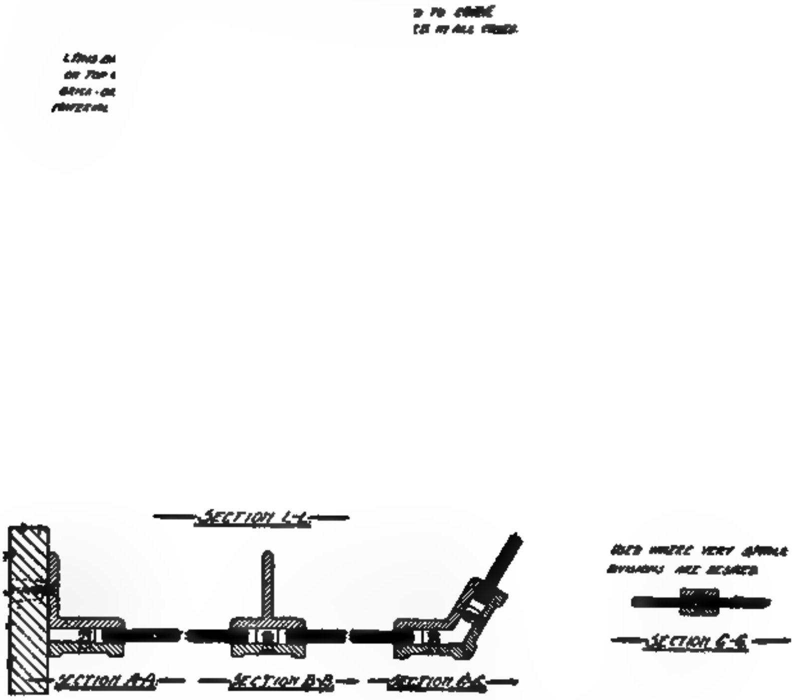


Fig. 220. Cast-Iron Store-Front Construction. Love Brothers, Inc.

are of cold-rolled copper and the finely cross-hatched members are of steel. As will be seen, no screws or bolts show on the outside to interfere with cleaning or to mar the lines of the moldings. The equal pressure of the sash-moldings all along the glass and the strength of the corner-bars and division-bars with their supporting brackets, assure the safe holding of the glass set in frames of this construction.

Fig. 222 † shows a vertical section of a metal-covered wood store-front construction † with the required relation of the glass-sizes to

* Manufactured by the Zouri Manufacturing Company, St. Louis, Mo.

† Manufactured by the Kawneer Manufacturing Company, Niles, Mich.

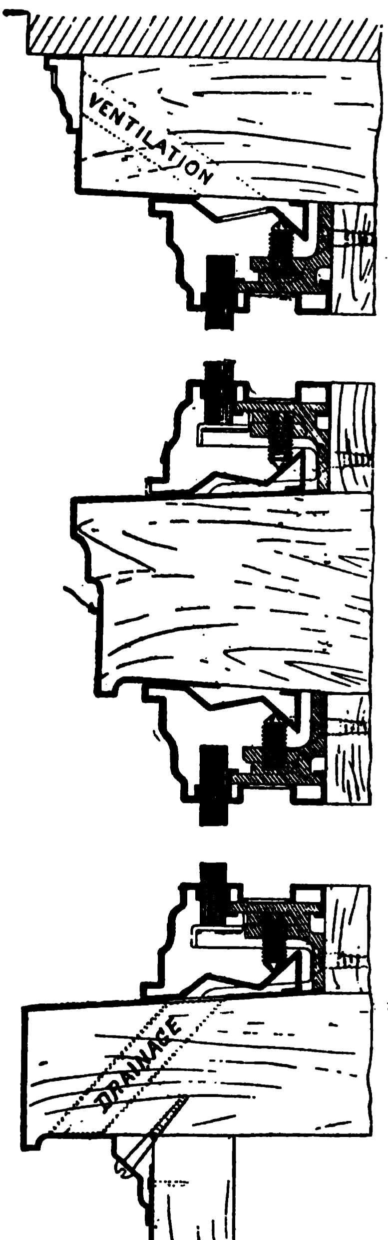


Fig. 221. Details of Zouri Store-Front Construction.

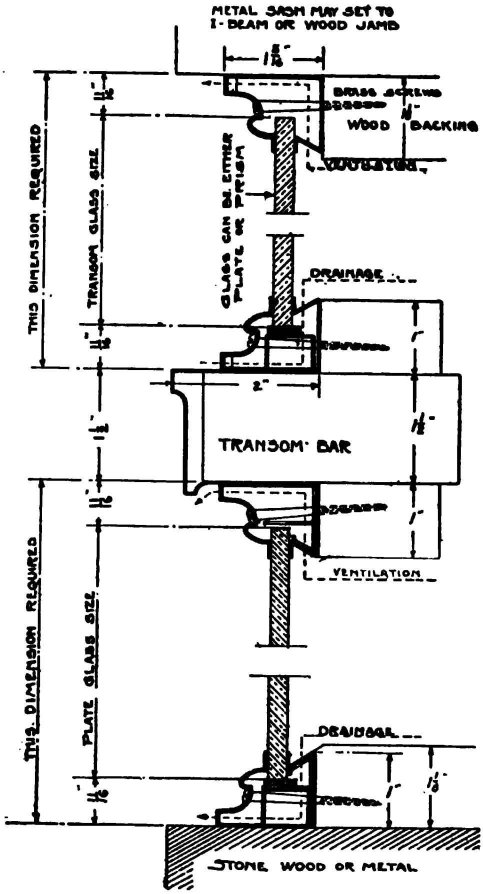


Fig. 222. Kawneer Store-Front Construction.

the length of the metal sash. Fig. 223 * illustrates in detail the construction of a store-front bulkhead with the sash hinged at

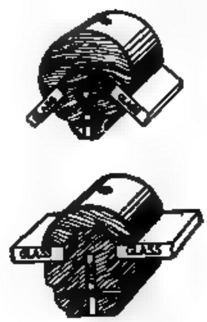


Fig. 224. Petz Corner-Post and Transom-Bar.

the bottom to swing in at the top. The sash is metal-covered at the factory and can be furnished in conjunction with the metal moldings covering the stationary parts of the bulkhead. Fig. 224 illustrates the section of the corner-post and the transom-bar of the Petz system of store-front construction.† As will be seen from the illustration, the construction is of wood, metal-covered and reinforced with steel. There are many other types and details of store-front construction but sufficient data has been given to explain this branch of carpenters' work.

Fig. 223. Kawneer Store-Front Bulkhead.

5. WINDOW-GLASS AND GLAZING. ‡

154. GLAZING.‖ 1. *General Methods of Glazing.* The glazing of windows originally belonged to the painters' trade, and when glass is broken, it is still customary to go to a painter to have it

* Manufactured by the Kawneer Manufacturing Company, Niles, Mich.

† Manufactured by the Detroit Show Case Company, Detroit, Mich.

‡ Much valuable information in regard to window-glass and glazing, was furnished by Mr. S. C. Gilmore of the Hires-Turner Glass Company, Philadelphia, Pa. (See, also, Articles on "Glass" in Chap. VIII, "Specifications.")

‖ See, also, Art. 150.

replaced; but custom has so changed in some parts of the country, that when new windows are to be glazed, the work is sometimes done at the mill or factory where the sashes are made, sometimes by the local glass-jobber in the town where the building is being erected, and again, in other localities, the glazing of new buildings is still done by the painter.

Common window-glass is usually set with putty and secured with triangular pieces of zinc called "glaziers' points," driven into the wood over the glass and covered with putty. In the best work, a thin layer of putty is first put in the rebate of the sash and the glass is then placed on it and pushed down to a solid bearing. This is called "back-puttying." The points are then driven about 8 or 10 inches apart and the putty applied over the glass and points so as to fill the rebate. Outside windows should always be glazed on the outside of the sash. Common window-glass has a slight bend in it, the result of its original cylindrical shape; it should be glazed, therefore, with the convex side out, as this reduces to a minimum the effects of the waviness when looking through it either from the outside or inside. Plate glass, in both window-sash and door-lights, should be back-puttied and secured by wooden beads.

2. *Leaded Glass.* It was formerly a common practicc for architects to name in the specifications a certain sum of money to be allowed by the carpenter for the leaded glass and to be expended under the direction of the architect. Where clear glass was used, the pattern was sometimes shown on the drawings and the glass was specified in the san.e manner as any other work. When colored glass was to be used, it was customary to make a definite allowance and then to entrust the work to a good art-glass manufacturer.

But leaded glass should be designed, furnished and put in place by those who are entirely familiar with its manufactuer and its limitations; the purchase of the same should be left entirely in the hands of the owner and no specification as to its price or make should be used by the architect. The colored-glass windows should show as much individual artistic taste as any other picture or decoration used in the building. The cheap and inartistic leaded glass is fast becoming a thing of the past and owners are confining themselves to purely works of art placed in some appropriate location in the building.

155. SHEET GLASS. 1. *General Description.* Common window-glass is technically known as "sheet glass" or "cylinder-glass." "It is made by the workmen dipping a tube with an enlarged end in the molten glass or 'metal' until from 7 to 10 pounds are gathered up. Then it is blown out slightly by the workman, taken on a blowing-tube and still further blown and manipulated,

until a cylinder about 15 inches in diameter and 60 inches long is formed. This cylinder has the two ends trimmed off, is then cut longitudinally and gradually warmed. It is then placed on a large flat stone supported by a carriage, where it is heated until it softens sufficiently to open out flat; the carriage is then pushed into the annealing-chamber and the sheet taken off." About the year 1910, sheet glass blown by machinery utilizing compressed air, was perfected, and the result has been a gradual decrease in its cost. The cylinder blown by compressed air is split open and flattened out in just the same manner and by the same process as in the mouth-blown cylinder.

2. *Grades and Qualities of Sheet Glass.* Sheet glass is graded as "double-thick" or "single-thick," and each thickness is further divided into three qualities, "first," "second," or "third," according to its relative freedom from defects. The price varies according to the strength and quality. It should be remembered that sheet glass is always wavy, the result of the flattening of the cylinder. Many suppose that by designating sheet glass, "crystal-sheet glass," or, "selected-sheet glass," or "sheet glass free from waves and imperfections," a sheet glass free from waves and blemishes can be obtained. The terms and names do not change the nature of this glass, which still remains sheet glass, characterized by the defects inherent in the method by which it is manufactured. To obtain a thin glass, free from waviness, plate glass, ⅛ of an inch thick, sometimes known as "crystal plate," or plate glass 3/16 of an inch thick, must be specified.

Since the improvement in the manufacture of window-glass in this country, scarcely any sheet glass is now imported for glazing purposes. A small amount of Belgian sheet glass is brought to this country and used along the Atlantic seaboard for picture-framing. The low prices of the American sheet glass, and its excellent quality, have practically forced imported sheet glass out of the market.

All common sheet glass, without regard to quality, is graded according to thickness, as "single-thick" or "double-thick." The thickness of the double-thick glass is a scant ⅛ of an inch while that of the single-thick averages about 1/12 of an inch. It is customary to use the double thickness for sheet glass over 24 inches in width. The best quality of sheet glass is specified as "AA," the second as "A" and the third as "B."

3. *Sizes of Sheet Glass.* The regular stock-sizes vary by inches from 6 to 16 inches in width. Above that they vary by even inches up to 60 inches in width and 70 inches in length for double thickness, and up to 30 by 50 inches for single thickness.

4. *Cost of Sheet Glass.* The prices for sheet glass, as for all

other clear glass, vary with the size, strength and quality. Prices are determined by a schedule or price-list, giving the price for each size, in both thicknesses, and all qualities; and from these prices a very large discount is allowed. Fluctuations in prices are regulated by the discount, the list usually remaining unchanged for a number of years. The present price-list (1913) has been in use since October 1, 1903. The only way to ascertain the price of a light of glass of a given size is to find it from this price-list, from which the discount, quoted by the glass-dealer, must be deducted.

The price per square foot increases rapidly as the size of the pane increases, so that it is much cheaper to divide a large window into eight or twelve lights than into two lights. Compared with the cost of the building, however, the glass is a small item and in the better classes of buildings each sash is usually glazed with a single light of glass. In factories, workshops, etc., where there is usually a large amount of glass-surface, the size of the lights is not of so much importance, while the saving by using small lights is quite an item; hence twelve-light and even sixteen-light windows are generally used in such buildings.

The following table shows quite clearly the relative cost per square foot of different-sized panes of American glass, the prices given being about an average for the whole country at the present time (1913).

TABLE IV.

COMPARATIVE COST OF AMERICAN SHEET GLASS PER SQUARE FOOT, BASED UPON A DISCOUNT OF 90 AND 20 PER CENT ON THE LIST OF OCTOBER 1, 1903.

Grades.	Size of lights in inches.						
	10x12	15x20	24x34	30x36	36x40	40x60	60x70
	Prices in cents per square foot.						
Double strength:							
First quality	7.	8.3	9.4	10.	10.8	14.	29.2
Second quality	6.	7.3	8.3	9.	10.	14.4	27.
Single strength:							
First quality	5.	4.8	6.4	6.8			
Second quality	4.3	4.5	5.6	6.			

5. *Crystal-Sheet Glass, 26-ounce.* This glass is made by the cylinder-process, but is a little thicker than the ordinary double-strength glass. It is probably the best glass made, next to plate glass, but owing to the method of its manufacture is necessarily characterized by a wavy appearance. If good glass is required for

first-class residences, hotels, office-buildings, etc., polished plate glass should be used. The latter invariably gives satisfaction, while sheet glass, no matter of what thickness, is usually disappointing in its appearance.

6. *Defects of Sheet Glass.* All sheet glass, when looked upon from the outside, has a wavy, watery appearance, like the surface of a lake slightly agitated by the wind; and when the sunshine falls upon it the irregularity of the surface is greatly emphasized. This characteristic of sheet glass is due to its being made in the shape of a cylinder and then stretched or flattened out into a sheet, and it cannot be wholly avoided. Besides this universal defect, the cheaper grades are often "stringy," "blistery," "sulphured," "smoked," or "stained"; so that, in looking through the glass, objects seen at a distance are deformed and distorted.

156. PLATE GLASS. 1. *General Description.* Plate glass is commonly known as "polished plate glass" because its surface is finely polished and thus made clear and transparent. It is more largely used every year for windows of fine residences, hotels and office-buildings, where transparency is desired from the inside and an elegant appearance required on the outside.

The process of manufacture of plate glass is entirely different from that of sheet glass. In making plate glass the metal, which is prepared with great care, is melted in large pots and then cast on a perfectly flat cast-iron table. "The width and thickness of the plate is determined by means of metal strips called 'guns,' which are fastened on, and on which a heavy, metal roller travels. The ends of the guns are tapered so that when the roller is at one extremity, it and the guns form three sides of a shallow, rectangular dish. The molten metal is poured on and the roller passed along slowly, forcing the metal in front of it and rolling out the sheet." The sheet is then annealed and forms what is known as "rough plate," which is used for vault-lights, skylights, floor-lights and the like.

"For polished plate the rough plate is carefully examined for flaws, which are cut out, leaving the largest-sized sheet practicable. The plate is then fastened to a revolving table by means of plaster of Paris, and two heavy shoes, shod with cast iron, are mounted over it. The table is then revolved and sand and water fed onto the surface; and the shoes revolve also, going over all parts of the plate and grinding it down to a true plane. Emery powder is then fed on, in successive degrees of fineness until the plate is made absolutely smooth and all grit removed. After this, new rubbers, shod with very fine felt, are put on and liquid rouge is added for the polishing. When one side is completed the other side is simi-

larly treated, the plate losing about 40 per cent in weight by the operation."

2. *Qualities of Polished Plate Glass.* For glazing-purposes there is but one quality of plate glass on the market. The best of this is selected for manufacturing mirrors. At one time, plate glass was extensively imported, but the gradually improving methods of the American manufacturers, as well as the great cheapening of the process have practically eliminated imported plate glass from the market. The American plate glass is equal in every respect to that which was imported.

The usual thickness of polished plate glass is from ¼ to $\frac{5}{16}$ of an inch, but it can be made thinner than this; and when required for residence-windows or car-windows, may be obtained in $\frac{3}{16}$ or ⅛-inch thicknesses. It is manufactured from the same thickness of rough plate used for the ordinary thicknesses, but is ground down thinner and, owing to the additional cost of grinding, as well as to the risk, is more expensive than glass of the ordinary thicknesses.

3. *Cost of Polished Plate Glass.* The cost of plate glass of ordinary thickness varies with the size of the lights. At the present time (1913) the net price of polished plate glass, glazing-quality, is about forty-five cents ($0.45) per square foot, for sizes of not more than 10 square feet per plate, fifty cents ($0.50) per square foot for sizes containing from 10 to 50 square feet per plate, and sixty-five cents ($0.65) per square foot for sizes containing not more than 120 square feet per plate. For larger sizes the price increases rapidly up to two dollars ($2.00) per square foot. The price, however, can be accurately determined only by means of a price-list and discount. The price-list now in use (1913) was introduced in March, 1910, and the discount is about 90 per cent. Plate glass $\frac{3}{16}$ of an inch thick costs 15 per cent more than glass of the regular thickness on account of the extra expense of grinding it down. Plate glass ⅛ of an inch thick costs from 25 to 40 per cent more than glass of the regular thickness.

4. *Sizes of Polished Plate Glass.* Plate glass is cut into stock sizes, varying by even numbers from 6 by 6 inches up to 144 by 240 inches, or 138 by 260 inches.

157. COMPARATIVE COST OF DIFFERENT KINDS OF WINDOW-GLASS. The following table gives as accurate an idea of the comparative cost of the different kinds and qualities of glass used in this country for glazing as it is possible to give, the prices for the sizes being the present (1913) net, average prices. The first column of the table gives the kinds of glass, and includes both the American plate and the American sheet glass. The other columns of the table give the sizes of the different lights in inches.

TABLE V.

Comparative Cost of Different Kinds of Window-glass.

Kinds of glass.	Sizes of lights in inches.			
	24x32	30x36	36x40	48x60
American Plate Glass				
Glazing-quality	$2.35	$3.38	$4.60	$9.80
Crystal-sheet glass, 26-oz.	1.00	1.54	2.34	6.66
American Sheet Glass				
Double-strength, first quality	.54	.83	1.25	3.55
" " second quality	.47	.73	1.13	3.30
Single-strength, first quality	.37	.56		
" " second quality	.32	.50		

It will be seen from this table that the relative difference in the cost of plate and sheet glass decreases rapidly as the sizes of the lights increase. The prices in this table are based on the list of October 1, 1903, on a discount of 90 per cent for plate glass, 90 and 20 per cent for American sheet glass and 85 per cent, on "AA" double-thick, for 26-ounce crystal-sheet glass.

158. FIGURED ROLLED GLASS. This is a translucent or "obscured" glass with a pattern stamped on one surface. As the molten metal is rolled out on the table, the design, cut into the table, imprints itself into the soft glass. This kind of glass has almost entirely supplanted the ordinary ground glass because of its greater cleanliness. There are several popular designs on the market, made by various manufacturers. Some of the designs in common use are known as "Moss," "Maze," "Colonial," "Florentine," "Cobweb," etc. This glass is usually made ⅛ of an inch thick and in large sheets from 24 to 42 inches wide and from 8 to 10 feet long. "Maze," "Florentine" and "Cobweb" designs can be had either with or without the wire mesh in them. One important property of figured rolled glass is that of diffusing the light which passes through it.

159. PRISM GLASS. This glass is made with sharp prisms. These prisms are glazed horizontally in the window and by refracting the light throw it back horizontally into the rooms, adding very materially to the interior lighting. It is manufactured by several companies and can be procured from glass-jobbers in practically all the cities of the United States.

Glass prisms for lighting are made of pieces of glass of standard dimensions, about 4 inches square, with a smooth outer surface and an inner surface divided into a series of prisms. They are, in many cases, formed

into plates by the process of electroglazing, the edges of the prism-lenses being welded together, so to speak, by a narrow line of copper which gives the desired stiffness and strength for use in large frames, and also an attractive appearance considered by some to be superior to ordinary leaded work. These prism-plates can be made in any desired size, but for very large surfaces two or more plates, divided by means of metal sash-bars, are generally used.

The commercial value of these prisms depends on that property of glass which causes what is known as "refraction." Prism-plates receive the light from the sky, not necessarily from the sun, and refract or turn it back into the room which is to be lighted. With an ordinary window the light from the sky, passing through the glass, strikes the floor at a point not very far distant from the window. As the color of the floor is usually dark, reflecting perhaps only one-tenth part of the light falling on it, the rear parts of the room receive only a small portion of the light which enters the window. For this reason it has been necessary to make very high stories for deep rooms, in order to light, even moderately, those parts which are at a distance from the window. When prisms are substituted for the common window-glass or plate glass, the rays of light as they enter the glass are refracted, and by employing prisms of the proper angle, the rays may be given almost any direction. Moreover, by utilizing different prisms in the same plate, some of the rays may be directed to the rear of the room while others are thrown so as to strike near the front. The prism-plates do not increase the quantity of light entering the window, but simply redistribute it, directing it into those portions of the room in which it is most needed. By thus changing the direction of light-rays a room with a low ceiling can be better-lighted, than when sheet or plate glass is used.

To insure success in the lighting of interiors by means of prisms requires, however, a superior quality of glass, and careful scientific calculations and experiments, besides practical and attractive means of glazing and methods of installation. These requirements have been met by the several companies making these prisms and their products may be considered among the relatively new building materials. They have been very successfully applied to the lighting of dark rooms by daylight.

The application of prisms to any particular building depends upon the surrounding conditions and requirements, each case requiring some special treatment; but in a general way the various appliances used in the installations may be divided into four classes as follows:

1. *Vertical plates,* which are set directly in the sashes in place of the ordinary window-glass. They are commonly used for the transom-lights of store-windows and the upper sashes of double-hung windows. They may also fill the entire window.

2. *Foriluxes,* which are vertical prism-plates set in independent frames and placed in window-openings substantially flush with the face of the wall.

3. *Canopies,* which are external prism-plates in independent frames, placed over window-openings and set at an angle with the vertical, a position similar to that of an ordinary awning.

4. *Pavement prisms,* which are set in iron frames in the pavements or

sidewalks, in place of the ordinary bull's-eye lights. In connection with the pavement-prisms, when a well-lighted basement is desired, vertical plates of prisms, hung below and opposite the pavement-lights, are often used. These hanging, vertical plates receive the light from the pavement-prisms, and again changing its direction, project it horizontally into the basement. This feature is illustrated in Fig. 225, reproduced through the courtesy of the Luxfer Prism Company.

The canopies may be made either stationary or adjustable and may be employed in a variety of ways, combining the useful with the ornamental. The hanging, vertical plates lend themselves to a highly decorative treatment. In both the fixed and hanging vertical plates the prisms may be arranged to produce ornamental effects; and designs may be inwrought on the face of the prism-plates to correspond with the designs worked into the surfaces of the building and with the style of the entire façade. The

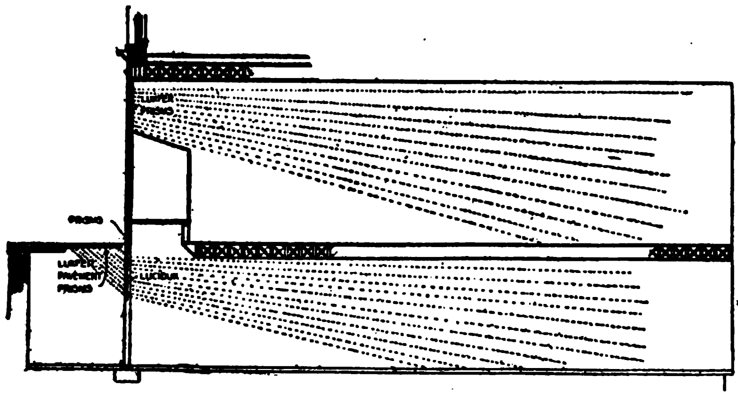


Fig. 225. Refraction and Transmission of Light by Prisms.

prism-plates weigh no more, and often less, than plate glass of the same size, while they are much stronger in resisting wind-pressure, the action of hail and the impact of flying fragments. Although transmitting a very large amount of light, these prism-plates are not transparent in the ordinary sense; and may thus be used as screens to hide unattractive views or to prevent persons looking either in or out of a window. At the same time a maximum quantity of light is admitted. The prism-plates, owing to the stiff, durable manner in which they are united by the electroglazing process, serve, also, as a fire-retardent or as a partial substitute for the ordinary iron fire-shutters. The copper glazing forms, as it were, a continuous rivet, which holds the individual prism-lights together, even after they have become badly cracked by the action of fire and water.

The details of the various makes of prisms are too complicated to be set forth in a few pages, but they are well described in the various handbooks and catalogues published by the different manufacturers. From a commercial point of view the special advantages of these systems of interior lighting are manifold. They transform rooms, particularly basements, other-

wise too dark for occupancy, into income-producing spaces; in many buildings they do away with the use of light-shafts, thus saving a large amount of valuable floor-space; and in all large or deep rooms they effect a great saving in artificial lighting. Once installed, there is no cost for maintenance. The extent to which these prisms have been used by architects, in both new and old buildings, shows that they have had a decided influence upon commercial architecture.

160. GLASS FOR SKYLIGHTS. 1. *General Description.* The glass ordinarily used now for skylights is either rough or ribbed skylight-glass, and since the great cheapening in the process of manufacturing glass with wire mesh in it, wire-glass is also being largely used for this purpose. (See, also, Art. 199.)

The sizes used depend largely upon the pitch of the skylight, small sizes being more desirable when the pitch is slight. The weight of rough or ribbed glass, with or without wire mesh is approximately as follows:

TABLE VI.

WEIGHT OF ROUGH OR RIBBED GLASS.

Thickness in inches.....	$^1/_8$	$^3/_{16}$	$^1/_4$	$^3/_8$	$^1/_2$	$^5/_8$	$^3/_4$	1
Weight in pounds	2	$2^1/_2$	$3^1/_2$	5	7	$8^1/_2$	10	$12^1/_2$

2. *Cost of Skylight-Glass.* The different kinds of skylight-glass in small quantities are quoted (1913) about as follows:

TABLE VII.

COST OF SKYLIGHT-GLASS.

Kinds of glass.	Cost.
Rough or ribbed skylight-glass, $^1/_8$-inch..................	6 cents per square foot.
Rough or ribbed skylight-glass, $^3/_{16}$-inch.................	8 " " " "
Rough or ribbed skylight-glass, $^1/_4$-inch..................	12 " " " "
Rough or ribbed wire glass, ¼-inch....................	16 " " " "
"Maze," "Cobweb," or "Florentine" wire-glass	20 " " " "
Sheet prism-glass	20 " " " "

161. WIRE-GLASS. Wire-glass is so called because midway between the two surfaces mesh wire is imbedded. In the event of the glass cracking, the wire prevents the pieces from falling out and is therefore of great importance in the manufacture of skylight-glass. Wire netting hung underneath the ordinary plain-glass skylight, especially in train-sheds, is apt to rust out from the fumes and gases; whereas wire-glass with wire mesh imbedded in it, is

not so affected. Furthermore, wire-glass has become practically a necessity as a fire-retardant in congested building districts. When glazed in metal sash and set in metal frames, it offers complete fire-protection where there are moderate exposures. The heat may crack the glass into thousands of pieces, but it stands intact, preventing the ingress or egress of the flames. The use of wire-glass in metal sash and metal frames usually compels lower insurance-rates.

Wire-glass can also be supplied with the surfaces polished, so that it can be glazed in windows without obstructing the view. Owing to the increased demand for fire-proof materials in buildings, the use of all kinds of wire-glass has greatly increased since the year 1908.

162. GLASS FOR MIRRORS. Mirrors are made by silvering one side of a sheet of polished plate glass. This is the only kind of glass suitable for making mirrors, because, unless the surface of glass is polished, the reflection is distorted. A generation ago, mirrors were made by the old-style process of pressing the glass by means of heavy weights onto mercury, backed by tinfoil, the affinity of mercury for tin forming an amalgam which protected the back of the mirrors and gave the reflection. This was a very slow and expensive process. During the last twenty-five years, prior to 1913, practically all of the mirrors made have been manufactured by what is known as the "patent-back" process, in which nitrate of silver is precipitated in a film over the surface of the glass, thus giving it the property of reflecting. This film is afterward covered and protected by shellac, varnish and paint. The improvement in this method of manufacture has made it possible to supply a good mirror in considerably less time, and at a very much lower cost, than when manufactured by the old-fashioned "mercury-back" process.

6. OUTSIDE-DOOR FRAMES.

163. GENERAL CONSTRUCTION OF OUTSIDE-DOOR FRAMES. The frames for all outside doors, whether in wooden or brick walls, should be made of plank not less than 1¾ inches thick and rebated on the inner edge for the door. In wooden walls the outside of the frames are finished with casings corresponding to those on the windows. In brick or stone walls a staff-bead or brick-mold is generally nailed to the outer edge of the frame, but sometimes the frame itself is molded and the staff-bead dispensed with.

Where the doors open in, the inner edge of the frame should be set flush with the plaster. In dwellings provision should always

be made for hanging a screen-door on the outside of the frame.

Fig. 226 shows the usual construction of the outside-door frames in wooden buildings. If the screen door is to be hung on the outside casing the latter should be 1⅛ inches thick. Sometimes the outer edge of the frame is rebated for the screen-door, as shown by the dotted lines. When the frame has a transom-bar this method of hanging the door is the better one of the two, and in all cases it has a neater appearance.

The shape of the sill shown in Fig. 226 is undoubtedly the best, but very often a plain plank is used and a narrow threshold placed under the door. Such a threshold is shown in Fig. 227.

Fig. 227 shows the usual method of making the outside-door frames for common brick buildings in the West. The jambs and head are usually made of 6-inch plank, with a 1⅛-inch brick-mold,

Fig. 226. Outside-Door Frame in Frame Building. Usual Construction.

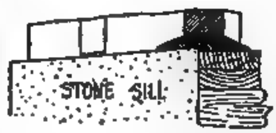


Fig. 227. Outside-Door Frame in Brick Building. Western Construction.

Fig. 228. Outside-Door Frame in Masonry Wall. Molded Jamb.

B, to which the screen-door is hung. If the brick-mold or staff-bead is of different shape the screen-door should set in a rebate in the outer edge of the frame. The dotted lines back of the jamb indicate short pieces of 2 by 4-inch studs nailed to the frame to hold it in place.

In dwellings a plain, stone sill with a wooden threshold is generally used.

Fig. 228 shows a molded jamb quite common in certain parts of the country. It is the opinion of the author, however, that a separate staff-bead is better, as well as a little less expensive. There is no particular advantage in making the frame more than 5¾ inches wide (not including the molding) other than that a wide frame is generally held more securely in the wall. In public buildings, and sometimes in residences, the stone sill is cut to the shape shown in Fig. 228, and no wooden threshold is used. This is a much better arrangement than that shown in Fig. 227, as the wooden threshold

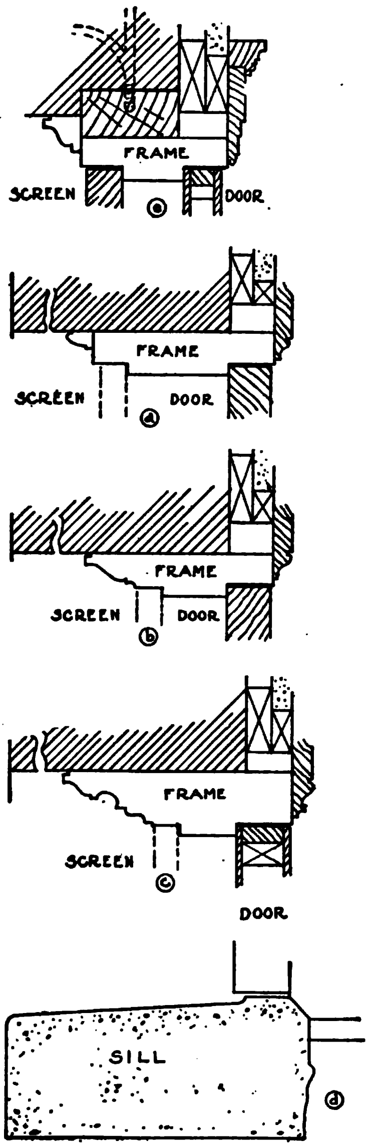


Fig. 229. Outside-Door Frames and Stone Sill in Masonry Walls. *a, b, c,* Door Jambs. *d,* Stone Sill. *e,* Frame for Exposed Situations.

often curls up, allowing the water to be driven under it; and of course the wood is not as durable as the stone.

Stone sills of the shape shown in Fig. 228 and in section *d,* Fig. 229, are frequently termed "thresholds." The top of the threshold, whether of wood or stone, should be from ⅝ to ¾ of an inch above the finished floor to allow the door to clear a carpet or rug on the inside. Fig. 230 shows other variations of outside-door frames for frame buildings, *a, b, c* and *d* being different types of door-sills, all of which should be of hardwood. Detail *e* shows the door-jamb in a frame wall for sill-section. *a.* Fig. 229 shows various details of outside-door frames in masonry walls. Sections *a, b* and *c* are much alike, the principal differences being in the contours of the moldings and in the thicknesses of the frames. Section *d* shows a stone sill quite commonly used. The sill should extend from the face of the wall on the outside through its full thickness to the finish on the inside. Section *e* is a good though uncommon construction and is used for exposed positions.

In brick or stone dwellings having outer walls 12 inches or more in thickness, it is quite common to make the door-frame with paneled jambs and head, as shown in Fig. 231. In stone buildings the wide frame saves something in the width of the stone reveal and in both stone and brick buildings permits the use of a thinner lintel over the opening. The stiles of the panels should be made 1¾ inches thick as in solid frames.

In public buildings, especially where the reveals are of stone, the door-frames are often made only 5½ inches wide and are set nearly flush with the stonework, as shown in Fig. 232. By this method the wall-opening is made practically the same width as the doors, and the apparent depth of the reveal, or thickness of the wall, is greatly increased. In such buildings screen-doors are not generally used. If the doors are to swing out, as required by many city building ordinances and as should be required in all public buildings, the door-frames should be set nearly flush with the outside face of the walls, as shown in Fig. 233. A door thus set may be swung back against the face of the wall, unless there is a very deep reveal, in which case a narrow jamb, rebated on the outside, may be set on the inside of the wall, allowing the door to swing against the reveal. Fig. 232 shows the door set to swing in.

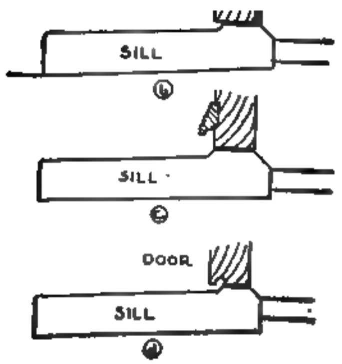


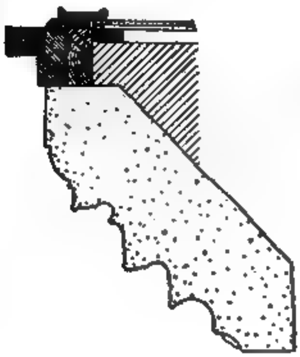
Fig. 230. Outside-Door Frames and Sills in Frame Walls. *a, b, c, d,* Wood Sills. *e,* Door-Frame in Frame Wall.

If the frame is set as in Fig. 233 it may be finished on the inside either by a plain board or panel, or the jamb may be plastered out to the frame, as is often done in churches. If the jamb is plastered, a ¾-inch strip of pine should be nailed to the back of the frame to form a ground for the plastering and to receive a small molding placed in the angle formed by the frame and plaster. The dotted lines in Fig. 233 show the manner of finishing the jamb with plaster.

Transom-bars over doors are generally made of solid plank, housed into the jambs about ½ an inch and rebated for the door on the under side, the upper side being made as for a window-sill. The outer edge of the transom-bar in dwellings should project to catch the screen-door, but should not cut into the staff-bead.

The material for outside-door frames should be clear, well-seasoned white pine, redwood, cypress, larch, Western cedar, or Douglas fir. If a hardwood finish is desired, ½-inch veneers over a pine

or other suitable wood core should be used. Outside veneered frames, however, do not stand well unless there is a deep reveal or the doorway is protected by a porch.



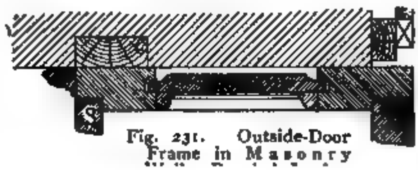


Fig. 231. Outside-Door Frame in Masonry

Fig. 232. Door-Frame with Deep Stone Reveal.

Fig. 233. Outside-Door Frame for Doors Swinging Out. Deep Reveal.

164. SECURING DOOR-FRAMES TO MASONRY WALLS. It is important to have the door-frames in brick or stone walls well secured to the masonry, otherwise the swinging and slamming of the doors in such frames will soon loosen them from the walls. The common method of securing a frame is to spike it to wooden blocks, each cut to the size of a brick and built into the wall. This does very well when the work is new, but after the wooden blocks have seasoned and shrunk the frame often works loose.

A better method is to spike blocks of wood to the back of the frame, if the latter is built in place. This is shown by the dotted lines in Figs. 227, 228 and 231. Even these blocks will not hold the frame firmly unless the brickwork or stonework is solidly built around them. The author strongly favors the use of iron anchors to secure the frames, especially when the doors are large and heavy. Two iron anchors shaped as shown in Fig. 234 and screwed to the back of each jamb, will hold a frame securely and not be affected by shrinkage. If there is no wooden threshold the bottom of the jambs should *always* be secured to the stone sill by means of iron

Fig. 234. Anchor and Dowel for Door-Frame in Masonry Wall.

dowels, either fastened as shown in Fig. 234 or let into the bottom of the jambs. Even where there is a wood threshold it is considered good practice to use these dowels.

7. CELLAR-STAIR BULKHEADS.

165. DESCRIPTION AND DETAILS OF CELLAR-STAIR BULKHEAD-CONSTRUCTION. An outside entrance to the cellar is almost a necessity in buildings that have a heating-apparatus in the basement. This entrance is sometimes provided by means of a door opening at the ground-level onto a landing of the cellar stairs; but more often it is provided by means of an outside stairway below the surface of the ground. In the Northern States this stairway should be covered to keep out the snow and also

Fig. 235. Outside Cellarway or Bulkhead.

to make the cellar warmer in winter. As a rule, the stairway, sometimes called a "rollway," or "hatchway," is placed at the rear of the building, so as not to be conspicuous; and if there is no window directly above, in the first story, it is a good plan to build a shed or porch over this stairway, with a door at the head. When this is not practicable the stairs must be covered with "trap-doors." This is generally accomplished in the manner shown in Fig. 235. A rough plank frame, *A, B, C, D,* is bolted to the side walls with ¾-inch bolts, about 18 or 20 inches in length, and built into the walls as they are laid, the nut on the head of each bolt being sunk

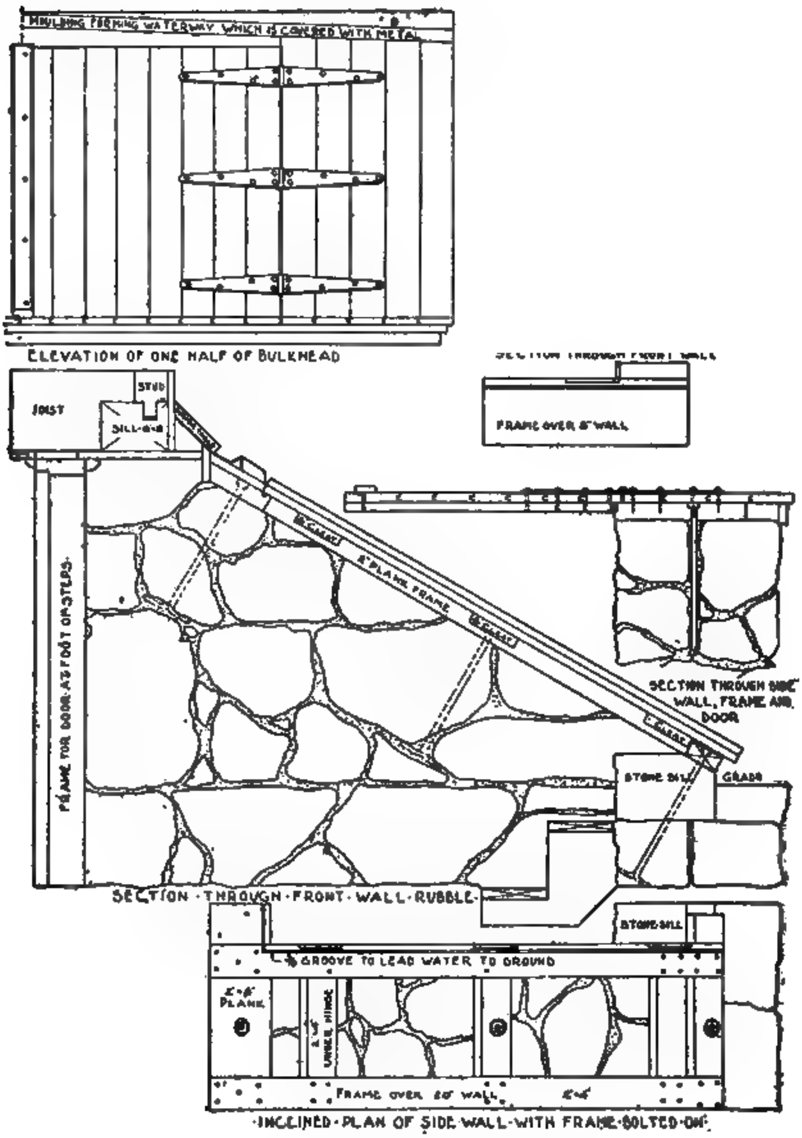


Fig. 236. Bulkhead over Outside Cellar-Stairs.

flush with the frame. The lower piece of the frame, *B*, is usually dressed, and forms the upper step. When the underpinning is brick-work the side-walls above the ground are usually made 8 inches thick, a single 2 by 8-inch plank being used for the frame. Piece *M* is a bevelled cleat, pitched and tinned to throw the water away from the doors.

After the frame is secured it is covered with matched-pine boards or ceiling and battened doors are hung to it by means of heavy strap-hinges, as shown in the drawing. When a skeleton frame is used, pieces of plank, *N, N*, should be placed under the hinges to receive the screws.

The only details of the construction of the ordinary "bulkhead" which require especial attention are those connected with the bedding of the frame in mortar, the bolting of it in place, the nailing of the doors with well-clinched clout-nails, the thorough fastening in place of hinges of proper size, and the provisions for keeping water out of the stairway.

The cleats for the doors should be 1⅛ inches thick and 5½ inches wide, with a mortise cut in the edges of the frame to receive them. It is a good idea to bolt the hinges to the doors with 3/16-inch carriage-bolts, as nails are apt to work loose in time.

In the majority of buildings no special provision is made to keep the rain-water from entering around the doors; but for all first-class residences, especially in those States which have a good deal of wet weather, the architect should make such provision in his specifications. A beveled cleat, *M*, pitched to each side, should be nailed to the casing above the doors, and this cleat and the space back of it should be covered with lead, zinc or tin, which should extend at least 2 inches up on the sheathing back of the water-table or siding. This will prevent the water that runs down on the wall from entering the joint above the doors. A small groove, also, should be made around the inner edge of the frame, as shown in the perspective, and in section *X*, to carry off what little water may enter the joints. The meeting-joints of the door may be protected by a batten, and a groove may be made in the edge of the standing door under the batten, as shown at *Y*. With these precautions very little water will enter around the doors and they will not be as likely to freeze up in winter.

Figs. 236 and 237 show plans, elevations and sections of other types of outside-cellarway bulkheads for stone or brick walls. The detailed construction of the various parts is in each case clearly shown.

OUNDATION

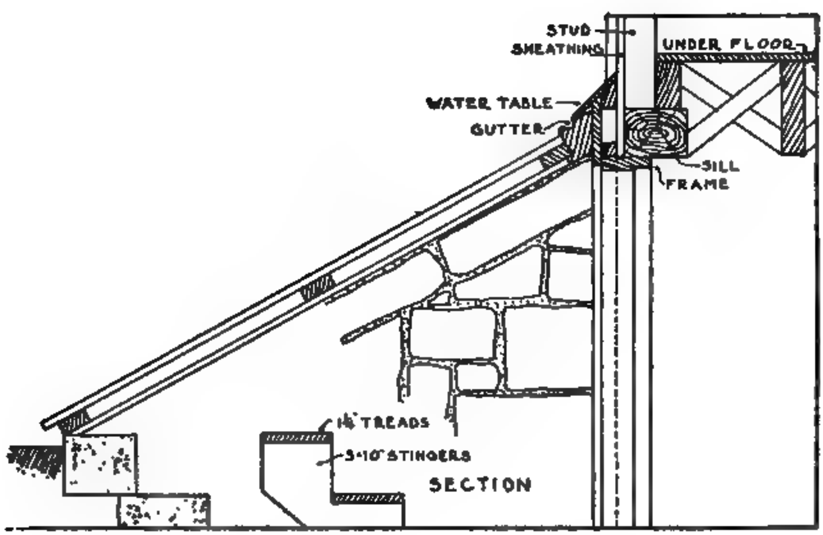


Fig. 237. Outside Cellarway-Bulkhead in Brick Wall.

8. SUPERINTENDENCE.

166. MATTERS REQUIRING SPECIAL SUPERINTENDENCE. The superintendence of the work described in this chapter will ordinarily be a very simple matter, especially if the work has been explicitly detailed and specified.

In regard to the rough boarding, the only inspection needed will be concerning the quality of the lumber and its nailing, and to see if it is put on as specified, that is, "close" or "open," or horizontally or diagonally. Each board should have two nails, preferably tenpenny nails, at every bearing, although eightpenny nails are commonly used. The superintendent should see, also, that the boarding under tin roofs has all its projecting edges eased off, and that the small knot-holes, if there are any, are covered with pieces of galvanized iron. Large knot-holes should not be permitted. (See Art. 133, page 169.)

The frames should be examined as soon as they are delivered at the building, to see that they are made strictly in accordance with the details and that the lumber used is of the required quality and thickness. The particular details to be looked after in the construction of the frames are those which are unusual in common work, such as the ploughing of the pulley-stiles into the outside casings and the rebating of the sills. The superintendent should see that the back of every frame is painted before the frame is set, if so specified, as it should be for good work. In brick buildings he should see that a piece of 2 by 4-inch studding is built into the wall under every window-frame (page 184) and that each frame is set plumb and is well braced during the building of the walls. In brick and stone walls the frames are easily pushed in or out before they are completely walled in, and they cannot easily be adjusted after the walls are up. It is, consequently, not uncommon to see frames out of plumb and showing a narrower or wider reveal at the top than at the bottom. The pulley-stiles, also, should be braced by boards set in between them to prevent the sides of the frames from being "sprung" toward each other by the brickwork.

In wooden buildings there is not much chance for the frames to move after they are once set and nailed; and it is only necessary to see that they are plumbed before nailing and that sheathing-paper is put back of the outside casings when these casings are placed over the sheathing.

The plumbing and securing of the door-frames in brick or stone walls should be carefully looked after as it is even more important to have these than it is to have the window-frames plumb and rigid. If a door-frame is not plumb the door will not swing properly, and

the slamming of a door soon loosens the frame if it is not well anchored (Art. 164).

When the sashes are delivered they should be examined to see that they are of the specified thickness and that the glass is of the kind specified. Plate glass can easily be distinguished from other glass by both thickness and reflection; and, as there is practically but one quality, there is little chance of an inferior article being substituted. When sheet glass is specified it is not so easy to determine the quality, although single-strength and double-strength glass can generally be readily distinguished; and first-quality glass should be free from flaws and streaks. If one of the special brands of glass is specified there will be no difficulty in seeing that it is furnished, as each light, in the first-quality glass, is labeled with the trademark.

All sashes and outside frames should be primed or oiled as soon as possible after they are delivered at the building.

CHAPTER IV.

Outside Finish and Roofing.

1. OUTSIDE FINISH IN GENERAL.

167. ORDER OF PROCEDURE. After a wooden building is sheathed or boarded the next step, ordinarily, is the finishing of the eaves and gables in order that the roof-covering may be put on and the building protected from the weather. While part of the workmen are putting on the roof, others are usually employed in setting the window-frames and outside-door frames and in putting on the outside finish, preparatory to covering the walls with siding or shingles. Sometimes the roof is shingled before the gable-ends are finished, the shingles being kept back from the ends of the roof and filled out after the raking cornice is put in place. The gutter or eaves, however, must be finished, at least on top, before the roofers can commence work, and it is also necessary that all of the outside casings, corner-boards, etc., be fixed in place before the walls can be covered.

168. MATERIAL FOR OUTSIDE FINISH. The material for outside finish should be eastern white pine, western white pine, cypress, larch, Douglas fir, or redwood, the two last-named woods, however, being seldom used east of the Rocky Mountains, except for piazza-posts or parts of large dimensions. In the better class of buildings clear, well-seasoned stock is generally specified, but on cottages a few small, sound knots are often permitted.

The various parts of the finish should be grooved and tongued together wherever practicable, the tongue being painted with white lead and oil just before joining the pieces. All joints should be so made that they are protected from the weather as much as possible, and the pieces should be fastened with nails or screws and not glued. All nail-heads should be sunk below the surface of the finish and the holes filled with putty. (See, also, Arts. 28 and 29.)

2. EAVES, CORNICES AND GUTTERS.

169. GENERAL CONSTRUCTION OF EAVES, CORNICES AND GUTTERS. The principal considerations of a

practical nature in designing the eaves of buildings and particularly those of dwellings, are the making of proper provisions for carrying off the water falling on the roof, whether in the form of rain or snow, and the providing of sufficient projection for the protection of walls from the water which drips from the eaves. The projection and finish of the eaves, also, have a very decided effect upon the architectural character of the building; and it is this consideration that generally determines them.

The eaves of dwellings are occasionally finished in the simplest manner by a gutter with a small molding underneath, the entire projection not exceeding 6 or 7 inches. When finished in this way they are called "close eaves" or "close cornices." Close eaves, however, although they may answer the purpose in some localities, are not as satisfactory as projecting eaves and, except on dormers, are now seldom used.

The holding and conducting away of the water is provided for by means of "gutters." These may be made of wood, tin, galvanized iron or copper and in various forms. In England cast-iron gutters in connection with wooden eaves are largely employed, but the author has not heard of their use in this country.

170. WOODEN GUTTERS. In New England wooden gutters are of more general use for dwellings and have proved very durable. These gutters are worked out of solid cypress or white pine, the common shape being that shown in Figs. 238, 241, etc. Cypress is much more durable than white pine. Several sizes of gutters are carried in stock by the larger lumber-dealers of Boston and other New England cities, but the common sizes are 4 by 6, 5 by 7 and 5 by 8 inches. In making the gutters the core is taken out in such a way that it may be utilized in making wooden conductors or downspouts. (See, also, Fig. 273,* Art. 177, "Wooden Conductors.")

When the length of the gutter between angles does not exceed 20 feet it may be made of one piece of wood, but for greater lengths two or more pieces are joined together by nailing and by flashing with sheet lead in the following manner. The two pieces to be joined are cut on a bevel to fit closely together and a rebate is made for a distance of 1½ inches on each side of the joint to a depth equal to the thickness of the sheet-lead flashing. A piece of sheet lead, 3 inches long, is then imbedded in the rebate with elastic cement and tacked around the edges with galvanized or copper tacks. This is a perfect joint and easily made.

With the possible exception of redwood, cypress is the best of

* Reproduced through the courtesy of the A. T. Stearns Lumber Co., Boston, Mass.

the woods for such gutters, but white pine, also, has been very extensively used in New England.

In nearly all other sections of the country the gutters are made of tin, galvanized iron or copper, tin being used principally for lining wooden forms. The shape of metal gutters may be varied to suit the pitch of the roof or the taste of the designer, since, with the exception of cheap, hanging gutters, metal gutters are not carried in stock but made to order as required. Metal gutters are described in connection with the examples of eave-construction.

171. EXAMPLES OF WOODEN-EAVE CONSTRUCTION. The manner of finishing the eaves of buildings varies with the style of the building, and also, to some extent, with the locality; and even the same architect varies his details more or less for each

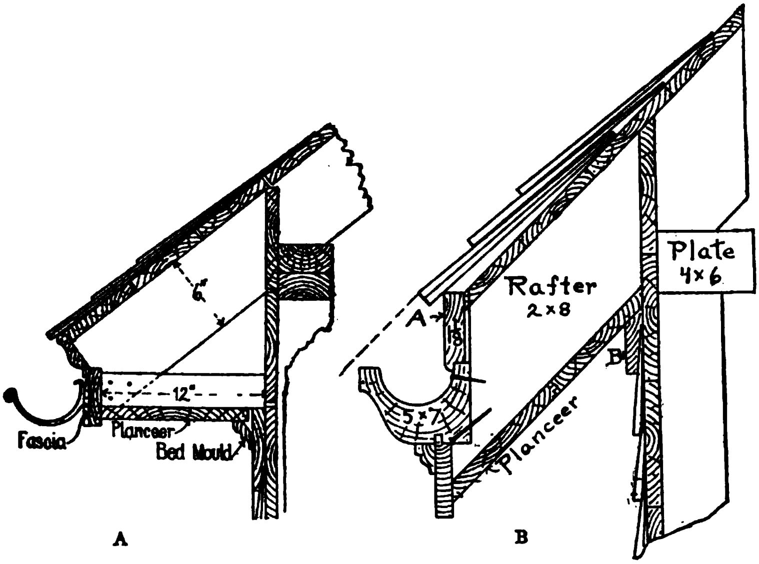


Fig. 238. A, Eave-Trough. B, Wooden-Gutter, Boxed Rafters.

building that he designs. All the common forms of wooden-eave construction, however, may be represented by four or five types. Brick and stone buildings, when erected in large cities, are generally finished with a stone, terra-cotta or metal cornice, as wooden cornices are not usually permitted within the fire-limits and are not as durable as those made of the other materials. Outside of the fire-limits, however, brick buildings as well as frame buildings with pitched roofs are generally finished with wooden eaves. For the cheaper class of buildings the construction shown in Fig. 238, *A* and

B, is probably more common than any other, the wooden gutter being used in the New England States and a tin or galvanized gutter in other sections of the country. The "planceer," "plancher," or "soffit-piece" may be either nailed to the bottom of the rafters, as shown at *B,* or carried across level, as shown at *A.* This form of cornice is generally termed a "box cornice," as the rafter-ends are "boxed" in. When an open, metal gutter is placed under the eaves of a box cornice, as at *A,* this construction answers its purpose very well. When a wooden gutter is used, however, as at *B,* it has been found, in the Northern States, that snow is apt to lodge in the gutter and that during many days in the winter when the snow on the roof melts a little at midday, the water runs down to the snow in the gutter and freezes there. The ice thus formed by this alternate freezing and thawing finally "backs up" over the gutter, under the first two or three courses of shingles and the water from the melting ice drips down inside the boxing and sometimes inside the walls. The only way to prevent this with a cornice like that shown at *B,* is to tin the gutter and extend the tin 2 or 3 feet up over the roof, a construction which is very unsightly.

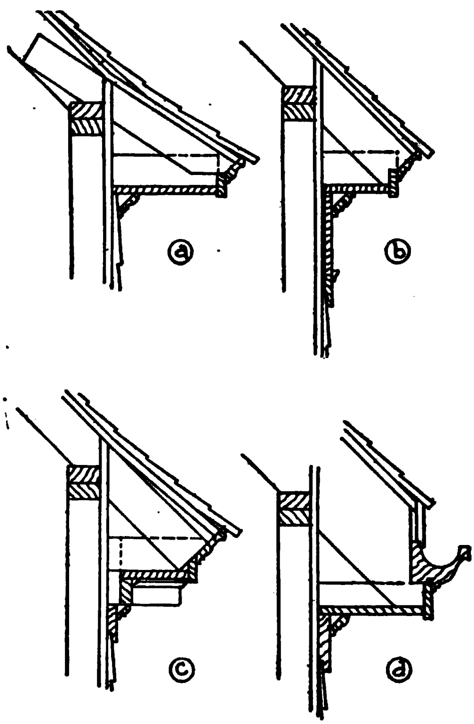


Fig. 239. Types of Box Cornices for Frame Buildings.

Fig. 239 shows four types of box cornices for frame buildings. Fig. 240 shows a section through the main cornice and balustrade of a frame residence near Franklin Park, Boston, Mass., designed in the colonial style by J. A. Schweinfurth. The details show the copper base for the balustrade, the tar-and-gravel roofing, the copper flashing at the edge of the wood gutter, the furring for cornice and the studding, plates, etc. The soffit above the consoles has a

slight incline and holes are bored where shown for the escape of any water.

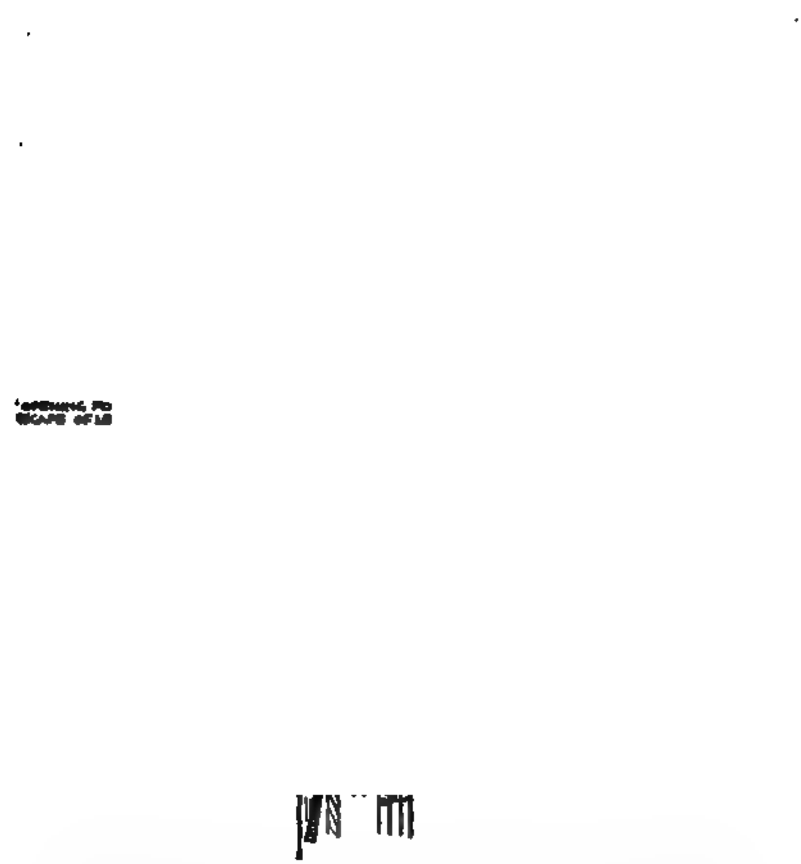


Fig. 240. Wooden Gutter. Cornice and Balustrade. Colonial Residence.

When wooden gutters are used, the best method of constructing the eaves, from a practical standpoint, is undoubtedly that shown

in Fig. 241. In this construction the rafters are exposed and there is an open space above the back of the gutter, so that there is little danger of ice backing up on the roof. The rafter-ends may be plain or ornamented and if a heavier material is required for the exposed ends than is necessary for the rafters themselves, the latter may be cut off on a line with the outside of the wall and false rafter-ends spiked to them and to the plates, as shown in Fig. 246.

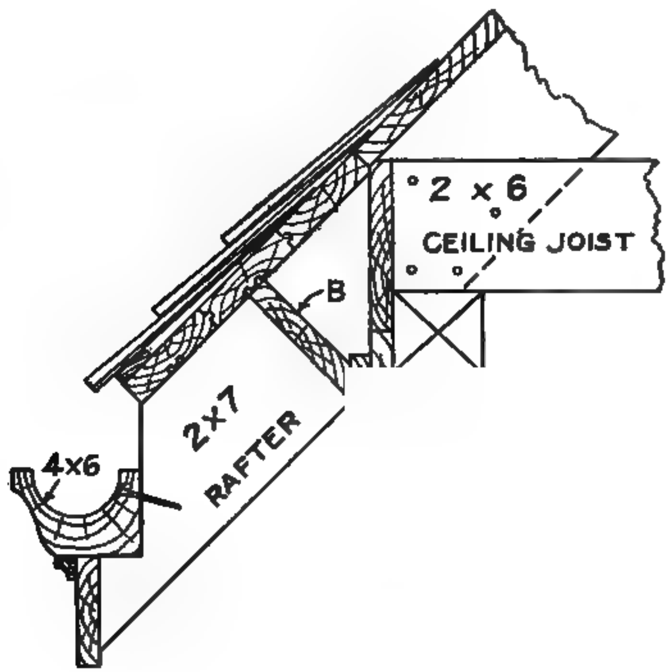


Fig. 241. Wooden Gutter, Open Rafters.

Fig. 244 shows details of open-timber construction for cornices. These cornices are suitable for use only in the cheapest work and although shown for shingle roofs they may be used for sheet-metal, tile or slate roofs. In this case the "show-rafters" are simply extensions of the main-roof rafters. Fig. 245 shows two details of open-timber cornice-construction for more expensive work than that shown in Fig. 244. In these cases the show-rafters are of better material and often sawed to pattern. They may be set at a different angle from the main rafters in order to give a slight curve or refinement to the lines of the roof at the eaves. It is better practice to form the curve in the upper sheathing as shown and

to keep the show-rafters and soffit straight. With slight modifications these designs may be used for either frame or masonry buildings.

Fig. 242. Wooden Gutter. Goose-Neck to Conductor.

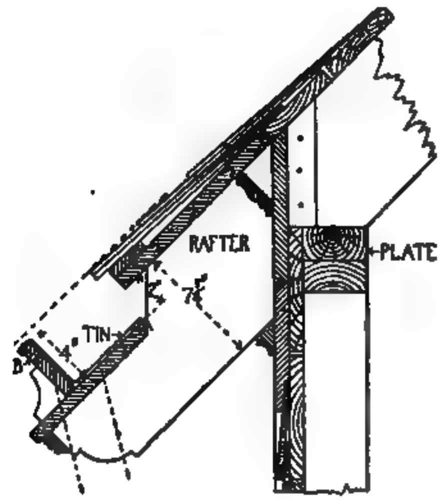


Fig. 243. Metal-Lined Gutter, Open Rafters.

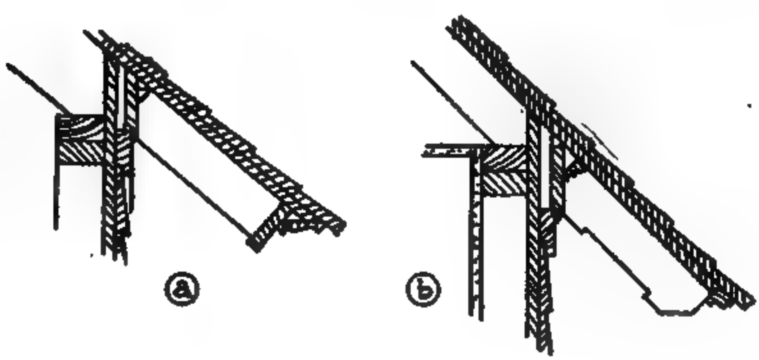


Fig. 244. Open-Timber Cornices.

In the Northern States and wherever a building is much exposed to the wind, a board *B*, Fig. 241, should be cut in between the rafters

and let into them about ¼ of an inch to keep the attic warm and to prevent snow from being driven through the cracks.

Where it is not practicable to leave an open space above the gutter the method of applying the latter shown in Fig. 242 is believed to be the best. In the Northern States when a gutter is placed under the

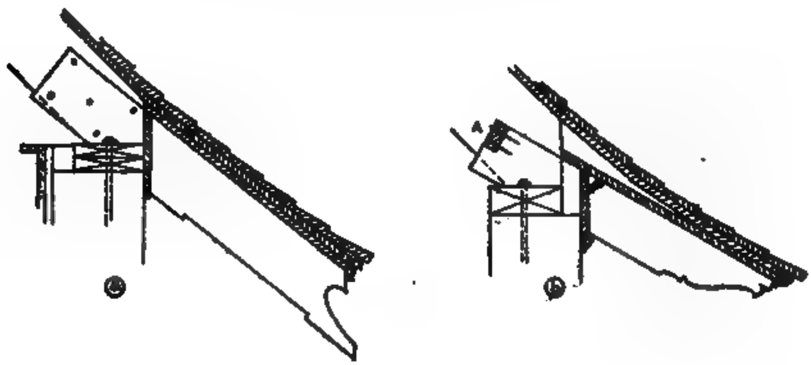


Fig. 245. Open-Timber Cornices.

edge of a roof, as in Figs. 238, 241, 247, etc., the outer edge should be kept just a little below the line of the roof so that the snow may slide off without striking the gutter. Very often the first course

Fig. 246. Wooden Gutter-Strip and Metal-Lined Gutter.

of shingles is raised ½ an inch above the roof-boarding, as shown in Figs. 238 and 241.

The projection of the eaves may, of course, be made to suit the taste of the designer, but with common box cornices the back of

the fascia is generally set about 12 inches from the wall-line. Open cornices generally have a projection of from 18 inches to 4 feet, the heavy projection being used principally for the effect of the shadow, and, in warm climates, to make the rooms cooler.

172. METAL-LINED GUTTERS. In many localities a form of gutter like that shown in Fig. 246 is commonly used. This gutter is formed by setting a strip of board, *B,* 3 or 4 inches wide, on top of the shingles and a few inches from the edge of the roof, with brackets, *A,* placed against it about every 24 inches to keep it in position. The V-shaped gutter thus formed is lined with tin, which should be tacked to the upper edge of the board *B,* the upper edge of the tin being turned over a half-round cleat nailed to the roof-

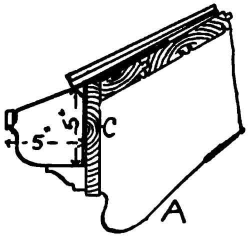


Fig. 247.
Dropped Metal Gutter.

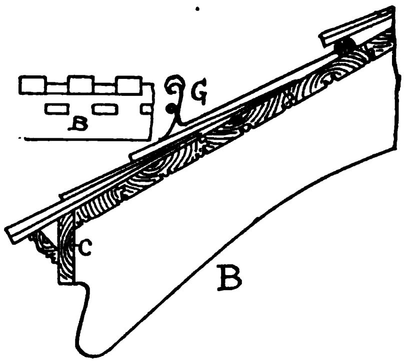


Fig. 248. Metal Gutter-Strip and Metal-Lined Gutter.

boards. The top of this cleat should be at least 2½ inches vertically above the edge of the board *B* and on steep roofs it is better to make the distance 3 or 4 inches. Fig. 248 shows a similar gutter made entirely of galvanized iron or copper. Either of these gutters may be placed on any projecting eaves, whether open underneath or boxed in.

The only objections to gutters of this type that the author has met with are that in cold climates they retain more or less snow, causing the water to back up on the roof, and that the projection of the roof below the gutter catches some rain, thus causing a slight drip. Such gutters detract somewhat from the appearance of the roof. They should always be placed outside the wall-line.

Fig. 243 shows a form of eave-construction which is very similar to that shown in Fig. 241, the only practical difference being in the form of gutter used. The gutter in Fig. 243 is made in about the

same way as the gutter shown in Fig. 246, but instead of being placed on the roof it is dropped below it. The board *B* should be 1⅛ inches thick and the brackets may be of any desired shape. This makes a very efficient cornice for medium-priced houses, especially in the Northern States, but rafters at least 8 inches deep are required to form the gutter.

Tin-lined gutters, also, are very commonly formed in the top of a heavy, box cornice, especially when the roof is quite flat or when the cornice is at the base of a French roof. Fig. 253 shows the manner in which the gutter is generally formed and Fig. 134 shows the same method applied to cornices surmounted by Mansard roofs. Such gutters should be of ample size, with a good pitch to the bottom and the tin should be carried to a considerable distance above the gutter.

Fig. 255 shows the cornice-details of a frame house of colonial design located in Seattle, Wash., and designed by Bigger & Warner for Mr. C. H. Lea. The shingles are of cedar and the siding of Washington fir, run especially large so as to show 5 inches on the face. The constructive wood of the house is of fir, the local building wood. Triglyphs in pairs, as shown, were used at the corners of the house and at intervals along the frieze, forming four divisions or intermediate spaces on the front of the house and one space at the end. The goose-neck connection from the gutter, through the soffit of the cornice, connects with a rain conductor-head placed against the wall just below the frieze and centered between the triglyphs. The illustration does not show this latter detail.

For the lining of gutters copper is the most durable material, but on account of its cost it is not used as frequently as tin. Only the best quality of roofing-tin should be used, of a thickness, like IX, not easily punctured. It should be painted on the under side before it is put in place and on the exposed side afterward. The phrase, however, in the specifications, "tin of IX thickness," does not necessarily mean anything of advantage, for the reason that there are so many good, bad and indifferent tins manufactured. Nor is it sufficient simply to specify "best quality." This might refer to the "best quality" of some particular "grade" and there are numerous grades of tin. Some grades refer to 8 pounds of coating to a box of 20 by 28-inch sheets. Others to coatings of 10, 12, 15, 20 and 25 pounds, and so on up to 40 pounds. All of these are made in the IX thickness and any one of them might be termed the "best" of its respective "grade." Hence a particular "grade" of those manufacturers whose products are generally approved as standard should be specified.

Fig. 251 shows various types of tin-lined gutters, all but detail *m* being generally adapted to frame buildings. At *d* is shown an adjustable eave-trough. A solid, wooden gutter is shown at *g*. The gutters at *h, i, k, l* and *n* are sunk gutters, cut into the rafters. A gutter for a brick or stone building is shown at *m*.

173. EAVE-TROUGHS AND METAL GUTTERS. In most instances the simplest method of taking care of the water from the roof is to place a galvanized-metal or copper gutter under the outer edge and in large cities this method is probably more often followed than any other. There are many different eave-troughs and hangers on the market. The thickness of metal is the same for conductor-pipes as for gutters. In small places where there are no shops for making gutters, tin-lined or wooden

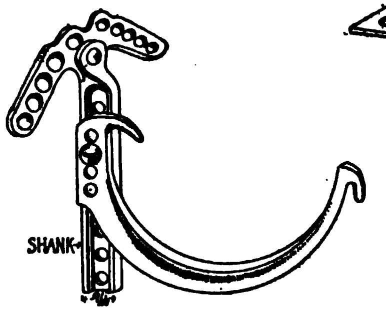


Fig. 249. Berger Eave-Trough Hanger.

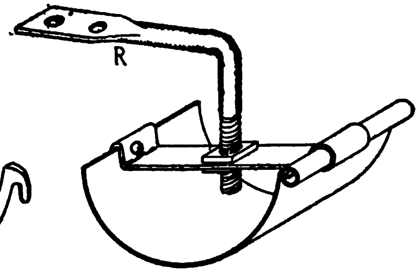


Fig. 250. Metal Eave-Trough and Hanger.

gutters are the cheapest. The best galvanized iron to use for gutters is either "Ingot" or "Toncan." "Monel," a non-corrosive metal composed of copper and nickel is sometimes used instead of copper. Copper is not affected by the atmosphere and conductor-pipes and eave-troughs made of it last as long as the building on which they are used. Galvanized material has a tendency to deteriorate and has a relatively limited life, unless it is repainted from time to time. While the first cost of copper is in excess of that of galvanized iron, in view of the saving in expense resulting from the great durability of copper, the latter material is often cheaper in the end. Should it ever become necessary to remove eave-troughs, copper conductor-pipes, etc., in making alterations, the copper material has value as scrap, whereas galvanized iron is worthless.

The cost of copperwork is about four and one-half times the cost of galvanized-iron work and the cost of the labor is about the same for each. If the work is plain, the relative cost of galvanized

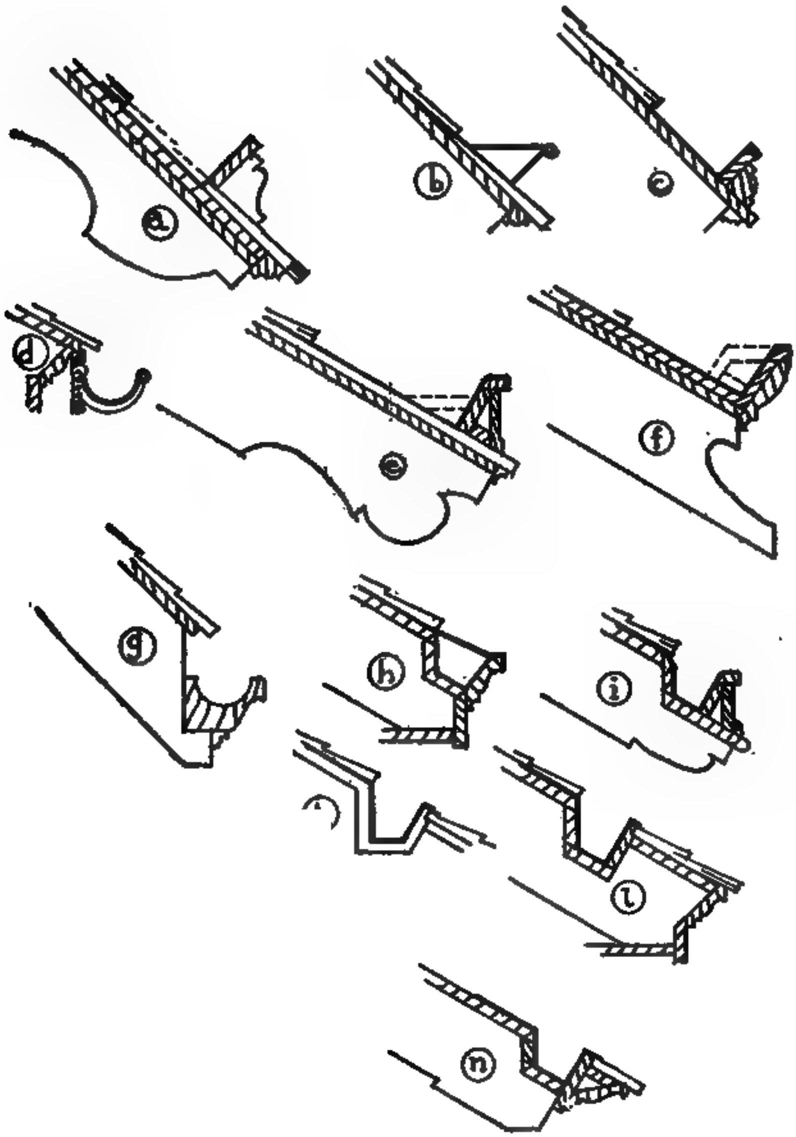


Fig. 251. Types of Gutters. *d*, Eave-Trough Hanger. *g*, Dropped Wooden-Gutter. *m*, Gutter for Masonry Wall. *a, b, c, e* and *f*, Gutters Above Rafters. *h, i, k, l* and *n*, Sunk Gutters.

ironwork is considerably less, whereas if the work has much ornamentation, the cost of the labor amounts to more than the cost of

the raw material if of copper; and the relative cost is not so great. For plain work the cost of the labor amounts to approximately

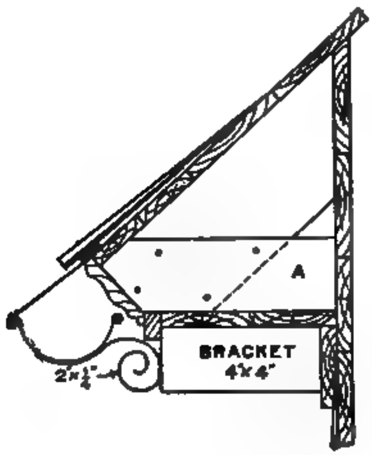


Fig. 252. Dropped Metal Gutter.

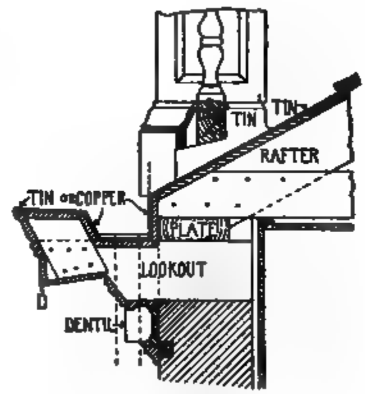


Fig. 253. Wooden Cornice and Gutter for Masonry Wall. See Fig. 254.

Fig. 254. Elevation of Cornice Shown in Fig. 253. Designed by F. R. Comstock.

twice the cost of the galvanized iron. For work of this description the relative cost of galvanized iron and copper is probably as one

is to two; whereas if the work contains much ornamentation, the difference is not so great. When it is necessary to paint galvanized iron every few years, the total cost at the expiration of ten years, for example, is even less for copper than for galvanized iron. (See, also, Art. 178.)

Gutters placed on the outer edge of the eaves may be made of many forms, the simplest being the half-round trough, as shown in Figs. 238, *A*, and 250. These troughs are usually either hung from the edge of the roof by a hanger such as is shown in Fig. 250 or supported by iron brackets, as shown in Figs. 238, *A*, and 249. The troughs are usually made of galvanized iron and of the form shown in Fig. 250, this being a stock pattern. On sheds and very cheap buildings tin gutters are frequently used, but they are far from durable and cannot be recommended. Where some pretense to ornamentation is made, as in the trough shown in Fig. 252, it may be made of 16-ounce cold-rolled copper, which, while much more expensive, will last almost forever.

When eave-troughs are used the author recommends that some form of hanger similar to that of the Berger hanger, of which one pattern is shown in Fig. 249, be specified, unless an ornamental bracket is preferred, as such hangers are far superior to the cheap affairs ordinarily used by tinners. The Berger hanger is made in two parts, the shank and the hook, which are bolted together. Several styles of shanks are made so that they may be screwed to the fascia or to the side of the rafter, or nailed to the top of the roof-boarding. The hooks are made 4, 5, 6, 7 and 8 inches wide. By means of the holes in the shank and hanger the height of the hook on the shank may be varied from 1/8 to 2 1/2 inches in order to give a proper fall to the gutter. These hangers can be applied to any cornice, old or new, and the hook may be readily adjusted at any time. They cost only about 6 cents apiece.

When no particular hanger is specified, one similar to that shown in Fig. 250 is generally used, as it costs 2 or 3 cents less than the Berger hanger. Such hangers, however, are very flimsy affairs, and not suitable for good buildings.

Eave-troughs, when made of good material, with slip-joints, make very practical gutters, which do not easily get out of order; and if a leak does occur it will not damage the building. They are not very ornamental, however, and their use is therefore confined largely to cottages, stables, porches, etc.

Next to the eave-trough, the simplest gutter for the edge of a roof is that shown in Fig. 247. This form of gutter is very extensively used. It makes a neat finish and answers its purpose very satisfactorily when provided with a sufficient fall to the outlets. It

Fig. 255. Cornice and Gutter-Details of House in Seattle, Wash.

is somewhat more expensive in most localities than a wooden or tin-lined gutter. It should be made of either galvanized iron, not lighter than No. 26 gauge, No. 24 being preferred, or of 16-ounce cold-rolled copper. All end-joints should be soldered and riveted unless the gutter is very long, when one or more expansion-joints should be provided. The back of the gutter should be turned up on the roof at least 3 inches.

About the only objection to this type of gutter is that when it is applied to overhanging eaves it is usually necessary to make it level, and when this is done it gets clogged with dirt and leaves after a time and prevents the water from draining perfectly. It also allows the water to freeze occasionally during the winter months, causing the joints to open. When the lengths of the gutter are short and the cornice has a good projection the want of a pitch to the gutter does not give serious trouble; but where the lengths are long or the projection very slight the gutter should always have a fall to the outlet of at least 1 inch in 20 feet. With a single gutter this fall is obtained by making the back of the gutter higher at the low end than it is at the other. The author has found that metal-workers seldom give any pitch to such gutters unless it is specified.

When a metal gutter forms the crown-member of a box cornice, as in Figs. 260 and 261, it is generally necessary to make the exposed face of the gutter level. To do this and also pitch the gutter, it is customary to make a false front for the latter, as shown in the drawings. This front is set level, but the gutter proper has a pitch of an inch or more, as may be desired. Wherever metal gutters are used on brick cornices this arrangement should always be adopted.

There is a slight objection to having the gutter at the very edge of widely projecting eaves, as a heavy "goose-neck" or long piece of bent pipe is required to connect it with the upper end of the conductor; and such connecting-pipes, being necessarily quite conspicuous, often mar the appearance of a building. For this reason many architects prefer, with such cornices, to place the gutter on top of the roof, as in Figs. 246, 248, etc., as by this arrangement a much shorter and less conspicuous connecting-pipe may be used.

When drawing the details of the gutter and cornice the draughtsman should always consider how the gutter is to be connected with the outlet-pipe and locate the former so that a neat and practical connection may be made. The outlet-pipe should always cut through the bottom of the gutter but, if more convenient, may be cut on a slant.

174. WOODEN CORNICES FOR CHEAP, WOODEN BUILDINGS. Figs. 256, 257 and 258 show a number of ex-

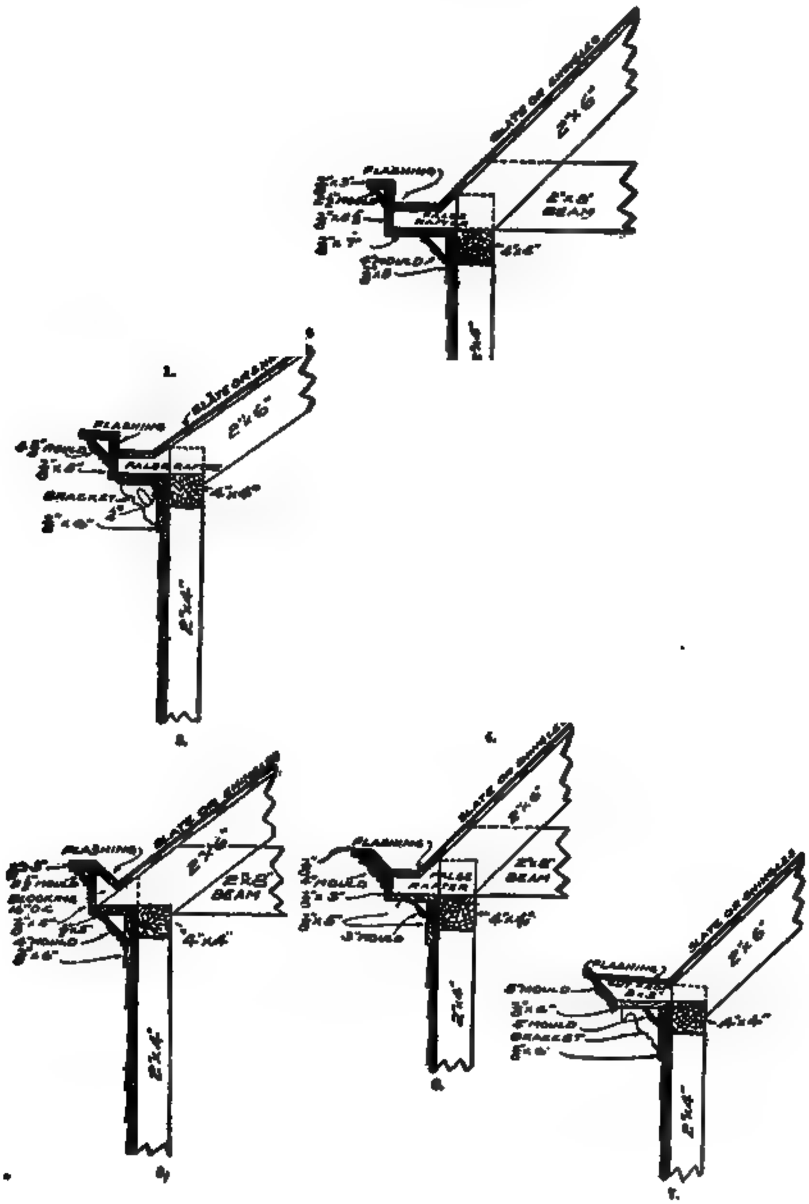


Fig. 256. Wooden Cornices and Gutters for Cheap Buildings.
From "Building Age."

amples of wooden cornices * for sheds, stables, factories and other inexpensive buildings.

From the cornices here shown the reader may obtain a general idea of the sizes used. The area of the roof and the amount of water to be carried off guide the architect or builder in determining the size of the gutter. The flashings shown, which are generally made of tin, copper or galvanized iron, are put on by the tinsmith or plumber. Moldings of stock pattern are placed on the cornices and can easily be procured by the contractor without delay. The brackets, also, can be taken from stock, as a large variety is kept on hand.

Type 1, Fig. 256, shows a gutter of a prevailing type. It is generally shaped by using a false rafter but can be formed by cutting the beam. The rafter used is as a rule 2 inches thick, but the gutter can be cut from timber of almost any size convenient to use. This cornice will resist any load which is likely to come upon it. The brackets shown are generally put on for appearance only and can be added or omitted as desired. Unless very strongly made they do not act as braces. The construction of the cornices shown in Types 2 and 3 is similar to that of Type 1. The finish of the trim differs slightly. As in the former type, (Type 1), the gutter is shaped by cutting a beam or using a false rafter. The brackets may be used or not as desired.

The cornice shown in Type 4 is not as strong as the types above described, but has given satisfactory results and is often used. Good strong brackets, spaced from 16 to 24 inches on centers, placed underneath the cornice, serve to strengthen and keep the gutter in shape, and are recommended for this construction.

A very strong type of cornice is shown in Type 5, as it is supported directly or indirectly by the larger timbers. The small pieces of blocking should be well fastened to the piece which has been cut to make the overhang. These blocks can be cut from timber of any convenient size. The finish of the cornice can be made to suit the taste of the owner or architect.

Type 6 meets the average requirements for gutters. It is obvious, however, that care should be taken to avoid too much weight coming on the trim, as very likely it would get out of shape if too heavily loaded. This construction is largely used on verandas, where the ceiling-joists are cut to shape on the end and where no great weight is expected to come on them.

Types 7 (Fig. 256) and 8 (Fig. 257) show forms of gutters which are coming more and more into favor in the construction of wooden buildings. The aim in this style of cornice is to avoid lodging-places for snow in spots where the sun will not melt it quickly. The top of the cornice is pitched according to the steepness and area of the roof, so that the water will not flow over it.

* The illustrations and matter relating to these cornices are rearranged and adapted by permission of the David Williams Company, New York, from an article by Mr. J. Gordon Dempsey, in the *"Building Age."*

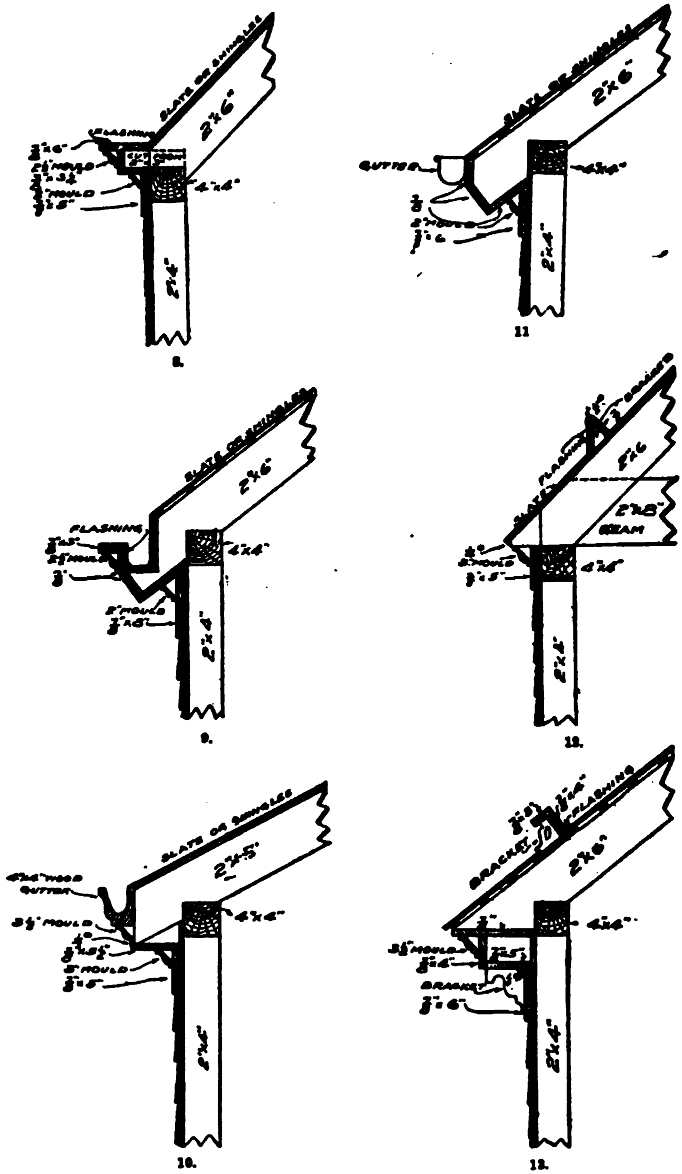


Fig. 257. Wooden Cornices and Gutters for Cheap Buildings.
From "Building Age."

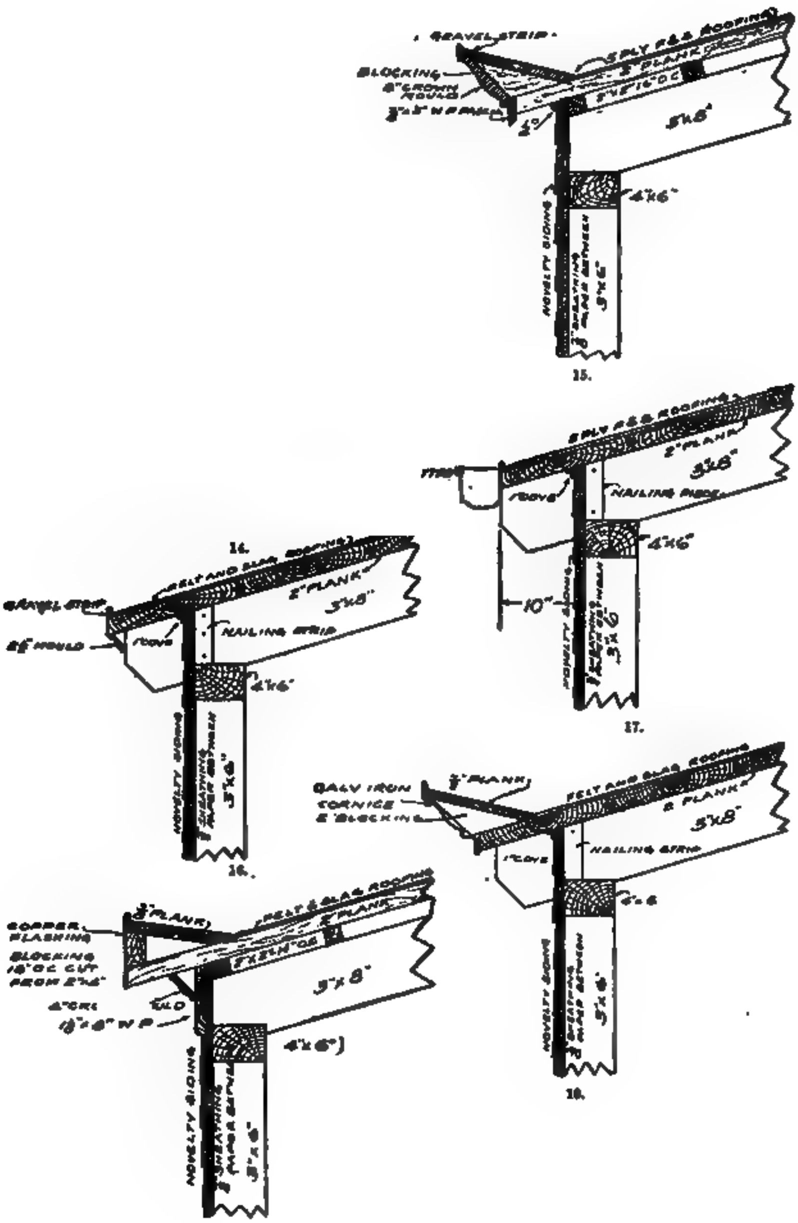


Fig. 258. Wooden Cornices and Gutters for Mills, Stables and Heavy Buildings.
From "Building Age."

In Type 9 the shape of the gutter is cut from the rafter. It is a sort of overhang-gutter, neat in appearance, strong, easily made and a great deal used. The amount of rain-water to be carried off governs the depth.

Type 10 shows a gutter which has at least one advantage over other types. As the shingles or slates may extend ⅛ of an inch over the inside of the gutter, no flashing is necessary. The water drips directly into the gutter. It is a one-piece gutter commonly made of cypress and gives good results.

A semicircular hanging-gutter is shown in Type 11. Any style of hanging-gutter can be put on in place of this.

A very cheap gutter is shown in Type 12. Small pieces of blocking, covered with boards of any convenient size, are placed from 16 to 24 inches on centers. A piece of half-round is nailed on the top, giving the gutter a curved shape. The flashing is placed over the entire gutter adding greatly to its strength. The area of roof and the amount of water to be carried should govern the size of the gutter which can be installed in any ordinary construction.

The gutter shown in Type 13 has a more elaborate finish on the overhang of the roof. This type is popular for churches, dwellings, etc. The gutter is held in place by brackets spaced from 16 to 24 inches apart.

The cornices shown in Fig 258, Types 14 to 19, are for use on heavy, wooden bulidings. Where a roof is covered with slag or gravel, gravel-strips are used, as shown, to keep the slag or gravel from rolling or being washed or blown off the roof by the wind and rain. They are made of metal, usually of copper, galvanized iron or tin. The high point of the gutter, as is generally understood, is at one end of the building and a slope is made to the low point at the other end and toward the leader which carries the water away. The widths shown for the rafters and other pieces are about the sizes generally used.

175. WOODEN CORNICES FOR BRICK OR STONE BUILDINGS.

Wooden cornices for brick or stone buildings are constructed in practically the same way as for wooden buildings, except that it is frequently necessary to build plank brackets or "lookouts" into masonry walls to support the woodwork. Ordinarily, on brick dwellings, the wall-fascia comes down but 1 or 2 inches onto the brickwork and is nailed to the plates; but occasionally it is desirable to cover up a foot or more of brickwork, as in Figs. 253 and 259, in which case it is necessary to build "nailing-strips" into the wall at the proper height to hold the finish.

Fig. 259. Cornice of Burnham Athenæum, Champaign, Ill.

The varieties of cornice-construction are innumerable, and the profile, projection, etc., of a cornice is a matter of design as well as of construction, the gutter, as already stated, being the principal constructive feature. As an aid to the architect in deciding upon the style of cornice to be adopted and in detailing the same, a number of designs of various types of cornices are given, which, with those already referred to, may be considered as covering the principal forms of wooden cornices.

Figs. 253, 254, 255, 259, 260, 261, 266 and 267 show various styles of box cornices on masonry buildings, that is, those in which the supporting timbers are concealed.

Fig. 253 shows the manner in which a classical cornice like that in Fig. 254 is generally constructed. The finish and the gutter are nailed to plank "lookouts" built into the wall about every 24 inches. In wooden walls these lookouts are spiked to the sides of the studs. The shape of the moldings may be varied to suit individual taste, but the pieces should be put together about as shown, and a drip should always be provided at the point *D*. The bottom of the gutter should be inclined toward the outlets, the tin being carried well up onto the roof, as shown. When the gutter is surmounted by a balustrade, special care must be taken with the tinning about the posts. The bottom rail of the balustrade should be kept at least 2 inches above the roof. In the Northern States snow is quite sure to lie back of such balustrades and the roof should be tinned for a considerable distance behind the railing, as shown in the figure.

Fig. 260. Cornice of Wood and Stone for Mansard Roof.

Fig. 259 shows a section of the cornice of the Burnham Athenæum, Champaign, Ill., designed Mr. J. A. Schweinfurth. The soffit of the cornice is paneled, the brackets being spaced from 2 to

3 feet apart. This forms a very suitable cornice for a classical building with a low, pitched roof.

Fig. 260 shows a common method of forming a wooden cornice at the base of a mansard or gambrel roof, when the walls are of masonry. The double gutter shown has already been described (Art. 173) and should always be used on such cornices. The wall-plates should, of course, be bolted to the walls in the manner shown in Fig. 259.

Fig. 261. Box Cornice on Residence, Denver, Col.

Fig. 261 shows a box cornice used by the author on a brick, city residence in Denver, Col. A stone or terra-cotta cornice would have been more appropriate, but could not be afforded. The gutter is the same in construction as that shown in Fig. 260, the crown-molding being level, while the bottom of the gutter has a fall of about 1 inch.

Fig. 262 shows a section of the cornice on a grammar-school building designed by Mr. E. M. Wheelwright for the city of Boston. The special feature of this cornice is the manner in which the rafter-ends are supported, it being in this respect somewhat unique. Usually the rafter-ends are made self-supporting, as cantilevers, and in this case the purpose of the lower brackets and beam is to

satisfy the eye rather than to support the rafter-ends. For a heavy building, however, such a cornice seems very effective and in case of fire would probably stand longer than those of the usual forms.

Open, wooden cornices, that is, those in which the rafter-ends are exposed, appear to be very popular at the present time and they undoubtedly involve the best construction for durability and fire-resistance.

Elaborate cornices generally have the rafter-ends made of white or yellow pine, dressed for painting or varnishing and spaced at regular intervals. These rafter-ends rest on the wall-plates and their upper ends are spiked to the common rafters or are spiked to planks set in between them. The roof-boarding over the projection must be sufficiently thick to

Fig. 262. Cornice of Grammar-School Building, Boston, Mass.

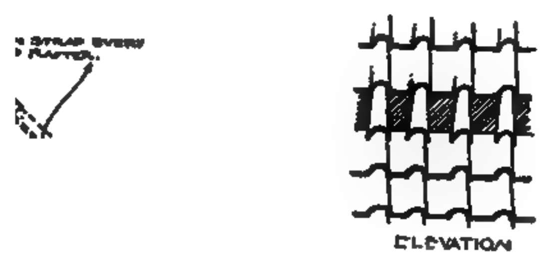


Fig. 263. Cornice and Hidden Gutter. House in Germantown, Pa.

prevent the shingle or slate-nails going through it. A covering of 1¾-inch planks, matched and beaded, is undoubtedly the best, affording a good "hold" for the nails and being, also, slow-burning. On dwellings, however, a more common covering

Fig. 264. Main Cornice, Jacobs House, Newport, R. I

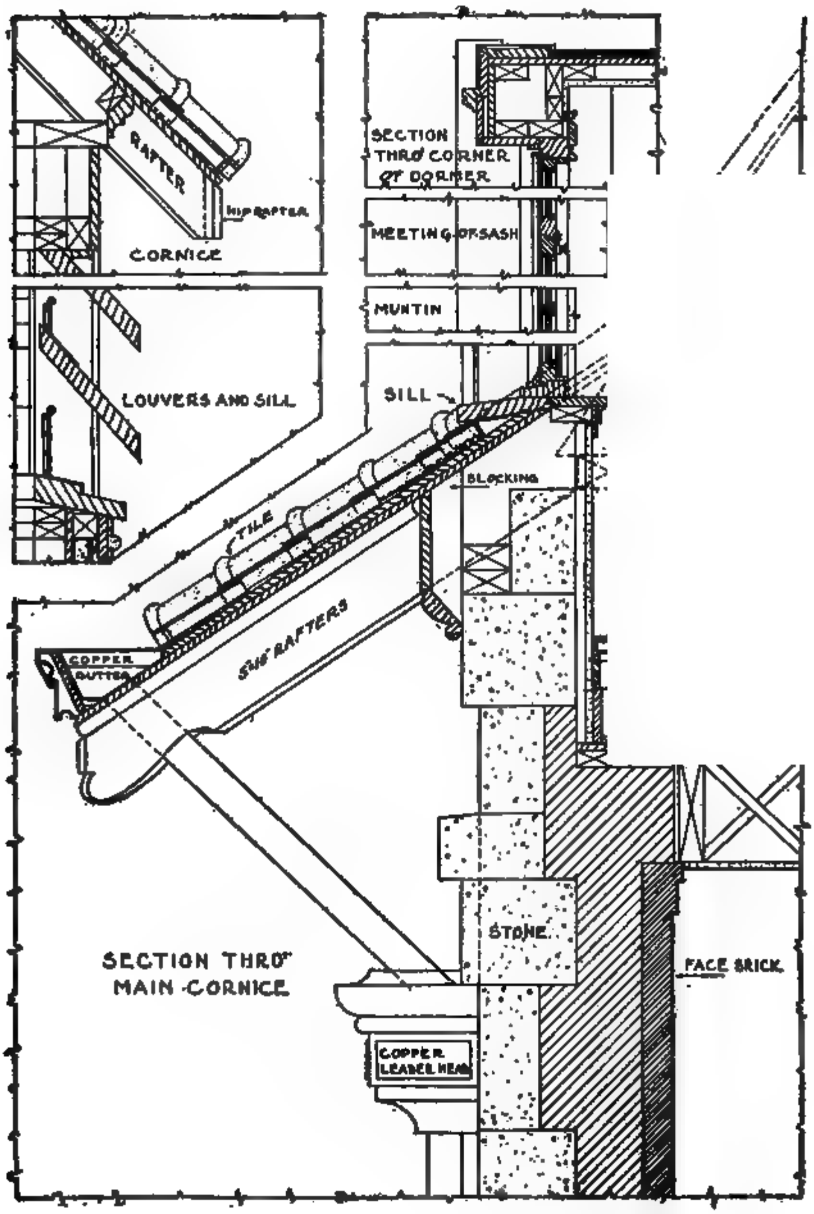


Fig. 265. Main Cornice, Roof-Ventilator, Dormer, etc., of Stable, Tarrytown, N. Y.

for the rafter-ends consists of ¾-inch white or yellow-pine ceiling, placed with the dressed side down and with the usual roof-boarding or sheathing laid on top. A single thickness of ⅞-inch ceiling is hardly sufficient for good work, although it has been used for shingled roofs. The rafter-ends are generally sawed to a pattern and present a better appearance when 3 or 4 inches thick.

A somewhat unusual method of forming the gutter in an open cornice in connection with a tile roof is shown in Fig. 263 and used

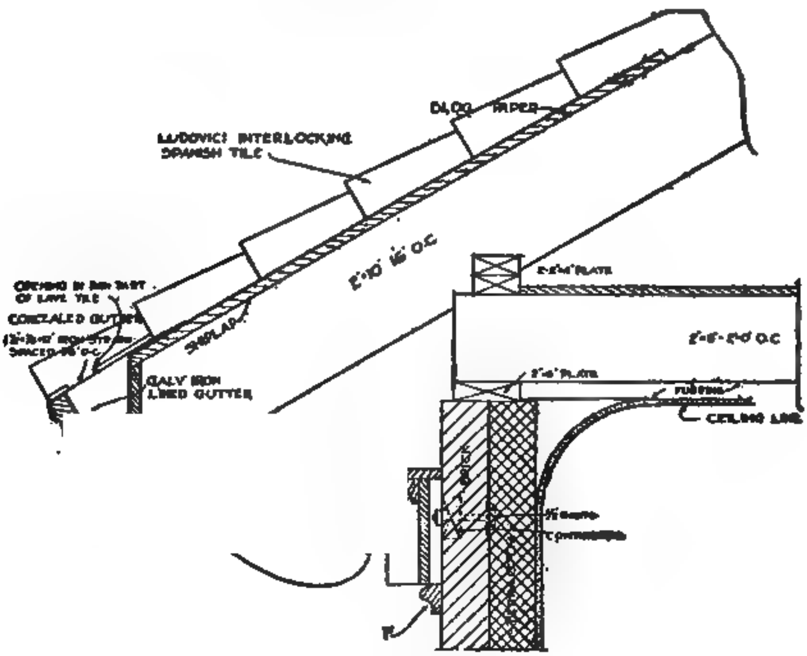


Fig. 266. Main Cornice of a Brick-Veneered Residence, Seattle, Wash.

on a residence in Germantown, Pa., designed by Frank Miles Day & Brother. The idea evidently was to conceal the gutter and thus show a thin roof-edge. As shown in the elevation, a portion of each tile was placed across the gutter. Aside from the appearance, the author regards this as a very important precaution, as the tiles tend to prevent snow from lodging in the gutter and as without them it would be likely to occasionally fill up solid with snow and ice.

Fig. 264 * shows the cornice and frieze of the residence designed

* Redrawn by permission from "Building Details," Frank M. Snyder.

by John Russell Pope for Mrs. H. B. Jacobs, Newport, R. I. The exterior finish of the walls of the house is white stucco, the roof is of red tile and the cornice, frieze, window-frames and sashes are of wood, painted white. The 2 by 10-inch lookouts are set 2 feet on centers, extend through the brick walls and are secured

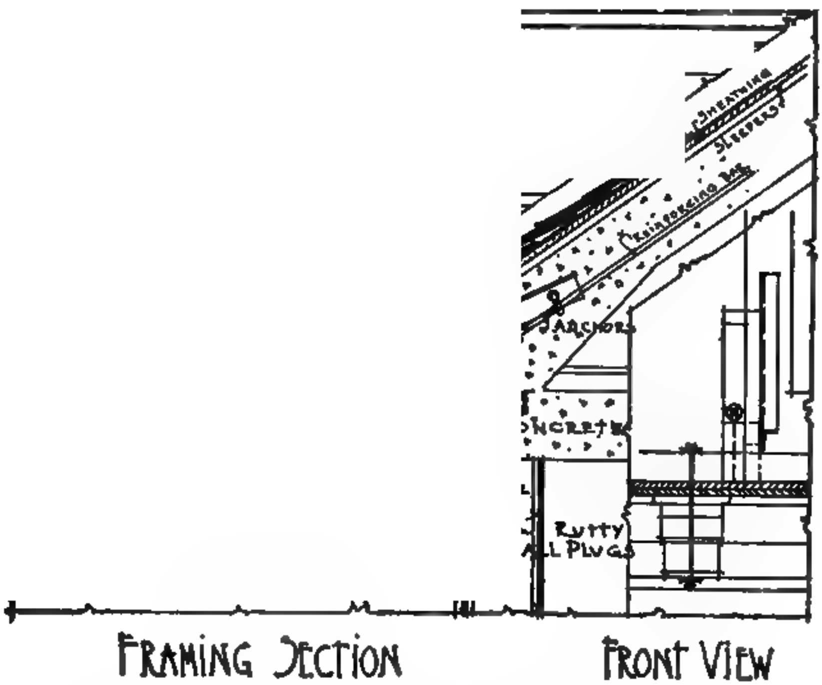


Fig. 267. Main Cornice of Dwelling, Bridgehampton, N. Y.

to the ceiling-joists. The gutters, cut into the rafters, are lined with copper and the cast-iron leaders run back to chaces in the inside face of the walls. The other details are clearly shown.

Fig. 265 * shows the details of the main cornice, roof-ventilator, dormer, etc., of a stable at Tarrytown, N. Y., designed by York & Sawyer. The wall-facing is a gray, rock-faced, local stone; the

* Redrawn by permission from "Building Details," Frank M. Snyder.

roofing of red, American, "S" tile; the exterior woodwork, with the exception of the sashes, chestnut, stained brown; and the sashes, white pine, painted white. The gutters, formed at the edge of the eaves, and the conductors or leaders and leader-heads, are of copper, the slanting leaders being 4 by 6 inches in cross-section. The drawings show, also, the construction of the cornice, louvers, sill, etc., of the ventilator on the ridge of the stable roof; and sections through the corner of one of the dormers and through the jamb, meeting-stile, muntin and sill of the frame and sash of the dormer casement-window.

Fig. 266 shows a section through the main cornice of a brick-veneered residence in Seattle, Wash., designed by Gould & Champney. The construction shows a box cornice, with the gutter cut into the ends of the rafters, at the edge of the eaves and lined with galvanized iron. This is a "concealed" gutter, having alternately open and closed sections and 1½ by ⅛ by 12-inch iron straps set 36 inches on centers. The rafters are 2 by 10 inches in section, set 16 inches on centers and are covered with the Ludovici interlocking Spanish tiles set on the "shiplap" roof-boarding.

Fig. 267 shows the construction of a wooden cornice and the method of anchoring and tying it to the reinforced-concrete roof-rafters on the house designed by Grenville T. Snelling for Mr. John E. Berwind, at Bridgehampton, N. Y. The general construction of this work is according to the system of the New York Holding and Construction Company. (See also Fig. 174.) The reinforced-concrete roof-rafters are set 3 feet 6 inches on centers and into each one of these is built a 2½ by 3½-inch angle-iron, securely anchored to it by means of a ½-inch bent reinforcing-bar. To each one of these angle-iron lookouts, a bracket, composed of a 2 by 8-inch rafter, a 3 by 8-inch hanger-piece and a 3 by 4-inch strut against the wall, is securely bolted. To the under side of these brackets two 4 by 4-inch plates are firmly nailed. These latter are incised into the 3 by 8-inch hanger-piece. It is to these 4 by 4-inch plates that the ornamental wooden cornice-brackets are bolted, as shown. The roof-sheathing is nailed horizontally to the upper side of the rafters of the roof-brackets and the sealing of the soffit of the cornice is nailed to the under side of the plates and the toe of the rafters. The "Rutty" wall-plugs, placed at convenient intervals in the joints of the wall-tiles, provide nailing-surfaces for a horizontal strip to which the finished architrave planceer-boards are nailed.

Fig. 268 shows the details of the roof-construction at the eaves of a building, the walls of which are constructed of the "Natco" hollow

tiles.* The drawing shows the constructional relation between the tiles, rafters, ceiling-joists, wall-plates, window-head, etc. A wooden plate is laid on the wall-tiles to receive the joists and rafters and is

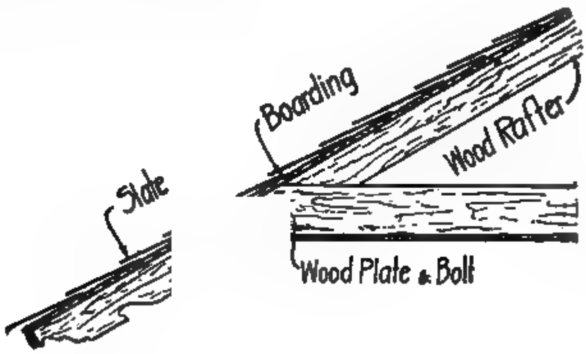


Fig. 268. Roof-Construction at Eaves on Walls of "Natco" Tile.

bolted to the concrete-filled portion of the tiles, as shown. Over the window-openings, where the tiles form a lintel, a steel reinforcing-rod is placed in one or more concrete-filled tile-sections.

176. WOODEN CORNICES FOR CHEAP BRICK OR STONE BUILDINGS.† Figs. 269, 270 and 271 show a number of examples of wooden-cornices for sheds, stables, factories and various heavy structures for different purposes.

In designing cornices for buildings of this character, the architect or draughtsman first takes into consideration the amount of water to be carried off and the size of cornice that will present the best appearance. The sizes generally used are shown in the illustrations. The details of the construction of the cornices are presented to give the reader a general idea of how they are built. There are very many designs and methods of construction, but those shown are very commonly used. The drawings show the cornices at the low points of the gutters where the leaders would be connected. There are numerous methods of making these connections and these details can be left to any reliable metal-man or plumber.

In most of the illustrations of Figs. 269, 270 and 271 it will be

* Made by the National Fireproofing Co., Pittsburg, Pa.

† The illustrations and matter relating to these cornices are rearranged and adapted by permission from the David Williams Company, New York, from an article by Mr. J. Gordon Dempsey, in the *"Building Age."*

noticed that at the bottom of the fascia-boards there is a slight angle in the cut. This detail is introduced to prevent any water which has blown against or flowed over the cornice from running onto the rafters or over the brick wall. The water that runs over the edge of the roof will drip off there at the bottom of the fascia-board. If all the water does not drip off at the end of the gravel-strip, it will drip off in the same way and not run onto the rafter nor against the brickwork of the building.

In some of the examples where slag roofing is used, the "gravel-strip" should more properly be called a "slag-strip"; but the name "gravel-strip" is used to designate this particular piece of flashing where either kind of roofing is used. The gravel-strip is placed on inclined roofs to keep the slag or gravel from rolling off and also to form a finish to conceal the ragged ends of the roofing. It can be made of copper, tin, galvanized iron or any metal desired, and is fastened with small nails to the outside of the cornice. On the inside of the gutter two layers of felt are laid and the flashing is nailed on top of these and covered with three additional layers.

The under side of the ends of the rafters or "lookouts" which project beyond the brick wall are cut in many different ways. As a rule it is cut to correspond with the angle of the mold. The one-quarter round or "cove," shown in the figures, is used to cover up any unevenness in the brickwork. It serves, also, as a wind-stop to prevent drafts over the top of the brickwork.

The figures have been arranged in four classes: 1, cornices with outside conductors; 2, cornices with inside conductors; 3, cornices with hanging gutters; 4, cornices with simply an overhang. Types 1 to 9 (Figs. 269 and 270) inclusive, have the outside conductors; Types 10 to 13 (Figs. 270 and 271) inclusive, the inside conductors; Types 14 to 16 (Fig. 271), the hanging gutters; and Types 17 and 18 (Fig. 271), overhang without gutters.

Type 1 (Fig. 269) shows a type of construction employed very largely with double roofs. The blocking is cut to the required angle from pieces about 2 inches thick, spaced from 16 to 24 inches on centers. The blocking is generally made about 2 inches thick, but almost any thickness that will meet the requirements can be used.

Type 2 shows a cornice for a roof having a single thickness of roof-planks. The construction here is somewhat the same as in Type 1.

Type 3 shows a cornice in which no fascia-board is used. A larger-sized crown-mold is used than in Type 2, but this should be made to suit the necessary height of the cornice. By letting the plank extend to the outside of the mold, as in Type 5, a smaller mold can be used.

Type 4 shows a cornice for a steeper roof. The roof-planks project about 2 inches beyond the ends of the rafters. These planks could be cut off

Fig. 269. Wooden Cornices and Gutters for Cheap Masonry Buildings.
From "Building Age."

9.

11.

Fig. 270. Wooden Cornices and Gutters for Cheap Masonry Buildings.
From "Building Age."

18.

Fig. 271. Wooden Cornices and Gutters for Cheap Masonry Buildings.
From "Building Age."

even with the ends of the rafters and the fascia-boards nailed on, giving a very different appearance.

Type 5 shows another cornice for a steep roof. The blocking in this case is fastened on the lookouts. The roof-planks are extended to the ends of the blocking and the mold placed under and nailed to it. This method of placing the mold gives a large, straight piece at the top of the cornice. It is in very common use.

Type 6 shows the roofing-planks extending 12 inches beyond the face of the wall to form the overhang on which the cornice is constructed. This overhang can be varied, for the sake of appearance, to suit the building. On a steep roof care should be taken in designing the cornice at the high point to make the rise in the gutter great enough to keep the water from running over it.

Type 7 (Fig. 270) shows a cornice with the lookouts and blocking closed in. This presents a very good appearance when the dimensions or "scale" correspond with that of the building itself. This type of cornice may be greatly varied by changing the details of the finish.

Type 8 shows a gutter formed by using a 3 by 4-inch piece with its upper corners rounded. The rounded corners are intended to give a better form for the flashing. The height of the strip varies with the area and pitch of the roof. When covered with good flashing-material this type of gutter will last a long time. It can be used with inside conductors by changing the position of the 3 by 4-inch strips.

Type 9 shows another type of gutter well adapted for buildings with moderately steep roofs. It is strongly constructed and covered with the roofing and is as strong as the roof itself. Although types 8 and 9 are not much used, they give as good if not better service than some of the others.

Type 10 shows the cornice of a double roof planned for an inside conductor, the finish being similar to that of Type 1 (Fig. 269). It is much used by architects and builders and is very strong.

Type 11 is another style of cornice for an inside conductor. No fascia-board is used to make up the finish. It will be noticed that the mold is placed slightly higher up, allowing more of the rafter to be seen and making the height of the cornice greater.

Type 12 shows a construction similar to that employed in Type 9, except that it is used with an inside conductor.

Type 13 (Fig. 271) is for an inside conductor, the construction being similar to that in Type 7 (Fig. 270). The height of the cornice however is greater.

Type 14 shows a semicircular hanging gutter of the most popular form. Straps spaced about from 16 to 24 inches on centers are fastened to the gutter, as shown in the figure and serve to reinforce it. The area of the roof and the amount of water to be carried govern the size of these gutters. The gravel-strip is formed as a part of the gutter.

Type 15 shows a hanging gutter to be used with an asbestos-shingle roof. The shingles, or slates if used instead, are allowed to project from ¼ to ½ of an inch over the inside edge of the gutter thus allowing the water to drip in. The straps shown on the gutter are used for the purpose of re-

inforcing it. If a felt-and-gravel roof is used instead, the gravel-strip is formed as part of the gutter.

Type 16 shows a square gutter used with a roof of a different design than that shown in Types 14 and 15. This design and mode of construction are much used on the ends of "saw-tooth" roofs. When the mold is placed under the gutter a good finish results. The mold can be dispensed with and the ⅞-inch white pine pieces run up to the roofing-planks.

Types 17 and 18 show types of overhangs without gutters and they may be varied to suit different designs and conditions. For example, in Type 17 both the crown-molds and fascia-boards may be left off, or the planks may project 2 or 3 inches beyond the edge of the rafters and the mold placed there. With the design shown in Type 18 a number of modifications are possible, such as cutting off the 8 by 10-inch timber at the end of the 6 by 8-inch piece and not using a mold; or using a mold or fascia-board alone.

3. CONDUCTORS, LEADERS OR DOWN-SPOUTS.

177. WOODEN CONDUCTORS. The pipes which conduct the water from the gutters to the ground or drains are called "conductors," "leaders" or "down-spouts," the first term, probably, being in more common use than the others. In the New England States, and possibly in some others, wooden conductors are often used on dwellings, but in most localities metal conductors alone are used.

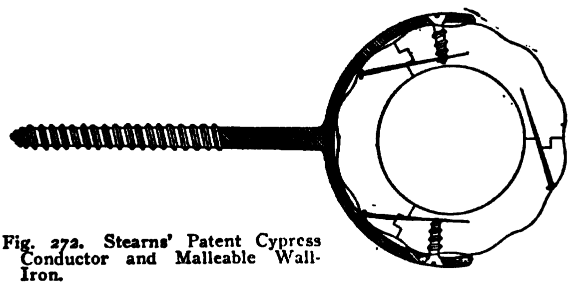


Fig. 272. Stearns' Patent Cypress Conductor and Malleable Wall-Iron.

The wooden conductors used in New England are made of two semicylinders of wood, about ⅝ of an inch thick and grooved and splined at the edges. These semicylinders are cut from the hollow portion of wooden gutters, so that the material costs practically very little. They are made of white pine or cypress, the latter wood being by far the more durable, and vary from 1½ to 4 inches in inside diameter. They are usually painted the same color as the trimmings of the house. The illustration, in Fig. 272, shows a section of a patented conductor,* in three pieces, with wall-iron attached. With the exception of the danger of splintering, caused

* Made by The A. T. Stearns Lumber Company, Boston, Mass.

by the water choking them up and freezing, cypress conductors are fully as durable as galvanized-iron pipes and much more durable than tin pipes. These conductors may be finished at the top by wooden, molded caps, turned and nailed to them. At the bottom they are usually cut off "square," about 12 inches above the ground. If they are to be connected with the drain, the lower end may be inserted in a piece of iron soil-pipe.

Fig. 273 * shows one method of applying cypress conductors and gutters or eave-troughs to buildings. The drawings show the con-

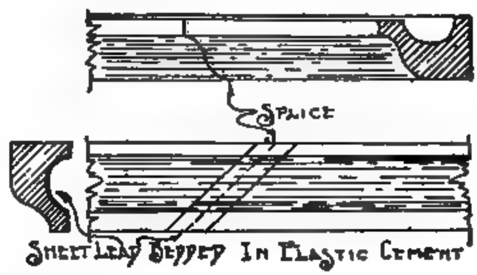


Fig. 273. Cypress Conductor and Gutter.

structional relation between the studs, rafters, wall-plates, box cornice, wooden eave-trough or gutter, lead goose-neck and conductor. Details are shown, also, of the construction of the gutter, including the sheet-lead lining bedded in elastic cement, and the manner of splicing.

178. METAL CONDUCTORS. These are usually made of galvanized steel or galvanized ingot-iron, although tin is sometimes used on buildings of very moderate cost and copper on public buildings and the best class of private buildings.

Tin conductors are soon eaten through by rust and are not at all economical in the long run; they are also easily dented.

Copper is the most durable of all materials for this purpose, and should be used when the rest of the construction warrants the ex-

* These drawings are reproduced through the courtesy of the A. T. Stearns Lumber Company, Boston, Mass.

pense. For the relative cost of galvanized ironwork and copperwork, see Art. 173.

Galvanized iron must be kept painted in order to be durable. If made of suitable thickness it is not easily dented. For ordinary conditions, No. 27 iron is sufficiently heavy; but when a pipe is exposed to hard usage, No. 22 or No. 20 iron should be used.* Copper conductors are usually made of from 14 to 20-ounce cold-rolled copper.† With both metals the joints should be soldered and riveted. Metal conductors, whether of galvanized metal or of copper, may be round, octagonal or rectangular in section; but should provide for expansion in case the water freezes in them as it often does. A corrugated, round pipe makes an excellent conductor and the square or octagon forms allow some expansion; a plain, round pipe, however, allows none. Plain and corrugated, round and rectangular pipes are carried in stock in many cities; but it costs but little more to have the pipes made to order and some metal-workers make their own conductor-pipes. When made to order they may, of course, be molded to suit the architect's design.

Fig. 274 shows at *A* a section of one form of pipe for specially designed work, while the section at *B* is one of the stock patterns, known in the trade as "square - corrugated." There are also "round-corrugated," "plain-round" and "plain-square" pipes. Rectangular-section conductors generally look better than those which are round and are, therefore, more often used where a better appearance is desired.

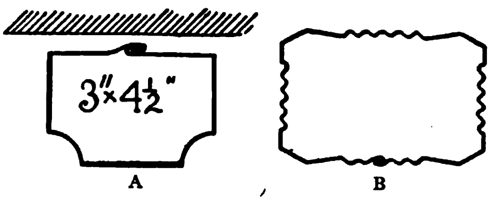


Fig. 274. Sections of Metal Conductors.

The stock sizes for metal conductors are 1½, 2, 2½, 3, 3½, 4, 5 and 6 inches for round pipes; 2, 3, 4 and 5 inches for square pipes; and 2 by 3, 2 by 4, 2½ by 4, 3 by 4, 3½ by 5, 4 by 5 and 4 by 6 inches for rectangular-section pipes. The stock sizes vary somewhat for galvanized-metal and copper pipes and some of the actual sizes, such as 1¾ by 2¼, 2¼ by 3¼ inches, etc., are commonly termed "2-inch," "3-inch," etc., pipe. Special pipes may be made of any size.

Conductors should be secured to the walls by malleable-iron

* The thickness of all sheet iron and steel is measured by the United States Standard gauge.

† The thickness of copper in sheets is given by weight per square foot, in fractions of an inch, or by Stubbs' or Brown & Sharpe's gauge.

fittings made for the purpose. These are usually driven or screwed into the wall about 5 feet apart and screwed to a wooden conductor, or wired to a metal one. Metal straps are often used, as shown in Fig. 275.

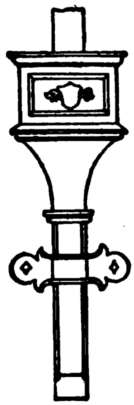


Fig. 275. Conductor-Head and Strap for Metal Conductor.

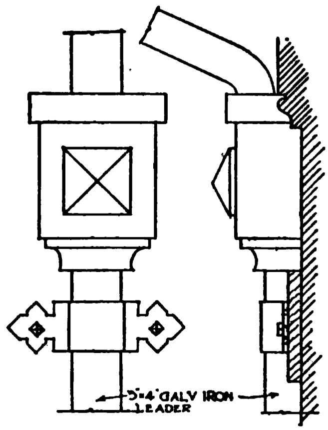


Fig. 276. Conductor-Head and Strap for Metal Conductor.

179. CONDUCTOR-HEADS, CAPS AND GOOSE-NECKS. On good work metal conductors are usually finished at the top with ornamental heads which may be made of various shapes, a common one being shown in Fig. 275. The connection between a conductor or conductor-head and a gutter is usually made by a lead pipe, called a "goose-neck," because it is often bent to that shape. For 3-inch conductors, 2½-inch pipes should be used and for 4-inch conductors, 3-inch pipes. Lead goose-necks are occasionally used with metal conductors, but more often pieces of the conductors themselves, either straight (Fig. 265) or curved (Fig. 264, cast-iron pipe for inside conductor), are used to make the connections; in fact the author has never seen a lead "goose-neck" in the West. When the conductors have ornamental caps the connecting pipes are merely placed inside of the caps. The goose-neck or pipe should be soldered to a tin or metal gutter; and generally a short piece of pipe is soldered to the gutter and the connecting pipe slipped over it. Fig. 276 shows the front and side elevations of the ornamental conductor-heads for the conductors used on the residence the main cornice of which is shown in Fig. 266.

180. WASTE FROM CONDUCTORS. Wherever possible the conductors should be connected with the sewer by means of

earthenware drain-pipes, laid below the frost-line and securely trapped. The trap should be provided with a "clean-out." When the conductors cannot be connected with the sewer, dry wells filled with stones may be sunk from 10 to 20 feet from the building and drains laid to them. For isolated dwellings, troughs of stone, cement or wood, laid above the ground, may be used to carry the water away from the walls, but in no case should the water from the conductors be allowed to run down on the foundation-walls.

181. INSIDE CONDUCTORS. It is often desirable and sometimes necessary to place the conductors on the inside of the walls. In such cases cast-iron soil-pipes 4 inches or more in diameter should be used (cast iron does not rust or corrode as badly as wrought iron) with joints calked and soldered. Special care should be taken to protect the pipes from frost and if possible they should be perfectly straight and vertical. When practicable it is good practice to fur the outer walls so that the conductors may be kept entirely inside of the wall-line. When this is not practicable, chaces or recesses should be left in the walls for the pipes, but there should never be less than 9 inches of wall between a pipe and the outer air; and it is advisable to pack the space around them with mineral wool. When the building is heated by steam or hot water, steam or hot-water pipes may be run up alongside the conductors, or Y's may be placed in the conductors in the cellar and steam or hot-water pipes connected with them.

Fig. 277. Stone Cornice, Gutter and Inside Cast-Iron Conductor.

The upper end of each conductor should always be protected by a galvanized-wire screen, to keep out leaves and other solid substances; and, where practicable, a hand-hole should be provided

near the top. Fig. 277 shows a detail for an inside conductor in a building designed by Frederick W. Perkins, architect. (See, also, Fig. 264.)

4. GABLES.

182. GENERAL CONSTRUCTION OF GABLES. The gable-ends of the roof on a wooden building are usually finished to accord with the design of the eaves. If the latter have a "close"

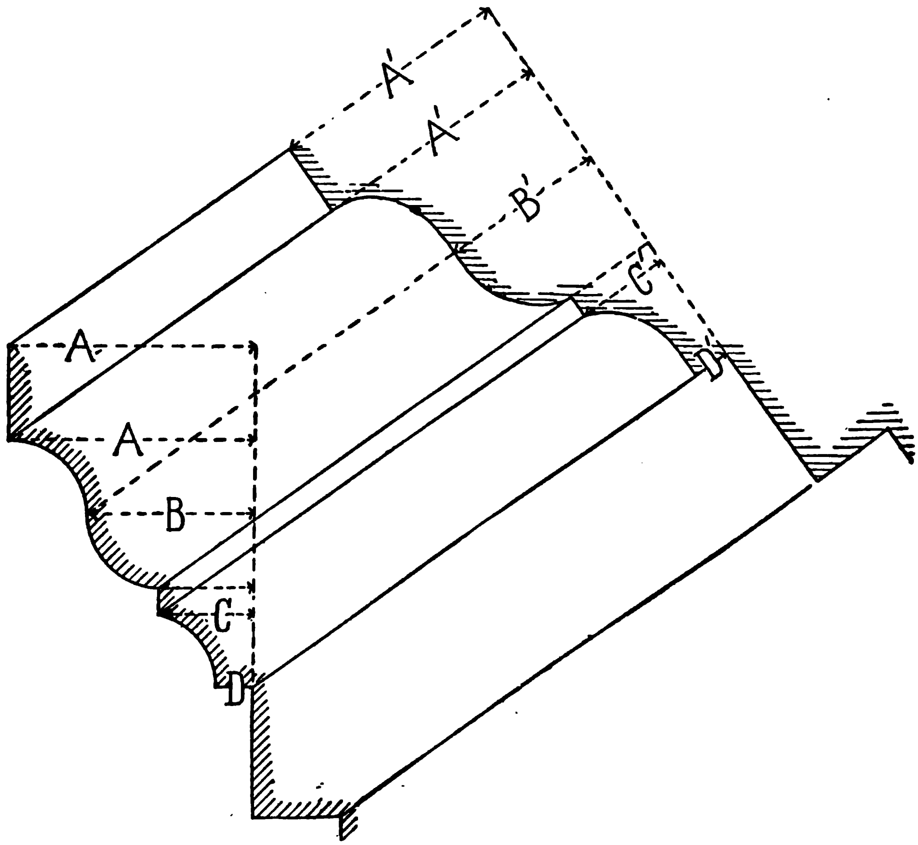


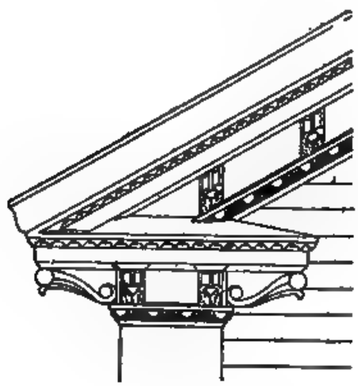
Fig. 278. Mitering Raking to Horizontal Moldings.

or "box" finish, a similar finish is carried up on the "rake" of the gables. When a box finish is used for the eaves, the "raking cornice" is usually boxed out to correspond. Raking moldings of the same section as the eave-moldings will not miter truly at the intersection, that is, if the eave-moldings are "plumb"; and to make

a proper intersection the raking moldings should be worked to fit the eave-moldings, as shown in Fig. 278.

The correct profile of the raking molding is obtained by drawing lines parallel to the pitch of the roof from the angles of the eave-moldings, and making the projections *A′*, *B′*, etc., of the same length as the corresponding projections *A*, *B*, of the eave-moldings. A molding-profile obtained by this method does not miter exactly but it gives the best results possible. When the eave-moldings are set at right-angles to the roof-surface, as shown in Fig. 283, the raking moldings of the same section will miter perfectly. Moldings set in that way, however, do not look as well as when they are vertical.

In buildings of "classical" or Renaissance design, the cornice, with the exception of the cymatium or crown-mold and upper fillet, is carried horizontally across the end of the building and the raking cornice finishes on it. In colonial work, and particularly on buildings with gambrel roofs, the cornice was often "returned" a short



A B

Fig. 279. Gable-End Finish on Returned Cornice.

distance, at the gable-ends, to make a stop for the gable-finish, as shown in Fig. 279, and this method is still often followed.

The correct method of returning the cornice under a gable is that shown at *A;* but the incorrect method shown at *B* has often been used on wooden buildings. The upper surface of the return is set on a bevel and is often covered with metal.

The gable-finish when boxed is supported by spiking lookouts to the wall, 2 or 3 feet apart, and nailing a plank to their outer ends, as shown in Figs. 283 and 285. The roof-boarding and moldings are then nailed to the outer plank and the planceer or soffit is nailed to the under side of the lookouts.

When the construction of the cornice leaves the rafter-ends exposed, the gable-ends are usually finished either with ornamental rafters, projecting 16 or more inches from the wall, as in Fig. 280, or with "verge-boards" or "barge-boards." The ornamental rafters may be supported by heavy brackets at the bottom and by the ridge at the top, or by lookouts; they are often used together, as in Fig. 280, the lookouts being tenoned and pinned to the outer rafters. (See, also, Art. 183.)

Fig. 280. Ornamental Gable-End.

183. VERGE-BOARDS OR BARGE-BOARDS. Verge-boards, sometimes called "barge-boards," are almost invariably used on frame buildings of the English Gothic or Tudor styles of architecture, and they may be used with almost any style of finish except the classical.

They are often highly ornamented by carving or panel-work, although they are frequently made plain, with chamfered edges. They should be made at least 1⅛ inches thick when the panel-molds are "planted" on, and not less than 1¾ inches thick when carved or chamfered. When more than 12 inches wide they should be framed for regular panel-work with 1¾-inch rails and stiles.

Verge-boards are applied and supported in many ways, some of the more common methods being shown in Figs. 281 to 286. With open eaves the verge-boards are generally, although not always, supported at the lower end by wooden brackets, which also serve to stop the gable-moldings, or belt-courses, as shown in Figs. 280 and 282, the brackets being used more as stops for the gable-finish than as actual supports.

With an eave-finish like that shown at *A*, Fig. 283, with the soffit of the eaves and raking cornice in the same plane, the verge-boards may be supported without brackets, as shown in section *C*, in which case the belt-courses on the gable should be placed above the point *E*, unless they are to be carried around the sides of the building. The wall under the soffit should be finished with a

board to correspond with the fascia under the eaves. The projection of verge-boards is seldom less than 14 inches.

Fig. 284 shows a rather peculiar method of stopping the verge-

Fig. 281. Verge-Boards, or Barge-Boards.

boards with "close" eaves. A ledge, or shelf is formed to close the lower end, as shown in the enlarged detail, Fig. 285, the eave-moldings being returned under it, to form a belt-course. Fig. 286 shows a very similar construction used in connection with a horizontal soffit under the eaves; in this case it is the only suitable method of stopping the verge-board. The top of the ledges or shelves shown in these figures should be pitched outward and covered with tin, zinc or copper. (See, also, Art. 182.)

184. GABLES ON BRICK OR STONE BUILDINGS. On brick and stone buildings of a public or enduring character and on all city buildings, the gable-walls are generally carried above the

roof and coped with stone or terra-cotta; but on dwellings not within the fire-limits the gables are usually finished in the same

Fig. 282. Verge-Boards with Bracket-Supports.

manner as on wooden buildings, the lookouts which support the raking cornices being built into the brickwork or stonework. Wooden cornices are much less expensive than stone or terra-cotta

Fig. 283. Verge-Boards Without Bracket-Supports.

cornices or copings, and on suburban residences they seem more appropriate and sufficiently durable. A plank should be bolted to the top of the wall to receive the sheathing and to stay the wall. If the finish is very deep it will be necessary, also, to build into

the wall at intervals, "bond-timbers" or wooden bricks, to which the finish may be nailed.

Fig. 288 * shows some of the details of construction of the gable over the entrance of the stable of Mr. Alexander Simpson, Jr., at Merion, Pa., designed by Walter F. Price. Detail *c* shows the front elevation of the projecting half-timber gable; detail *f*, the section through wall and cornice and the side elevation of lower part of gable; detail *a*, the vertical section through the gable and entrance; detail *b*, the section through the gable, raking cornice; and details *e* and *d*, the sections through the band-courses respectively over and under the gable-door.

Fig. 284. Verge-Board Finish with Close Eaves.

The sheathing and roof-boards are of hemlock, lined with sheath-

Fig. 285. Detail of Verge-Boards Shown in Fig. 284.

* Redrawn by permission from "Building Details," Frank M. Snyder.

ing-paper. The rafters, joists, flooring and other wood finish are of yellow pine. The roofs are covered with Mathew's unfading red slate, laid 8 inches to the weather. The hips, ridge and valleys are flashed with tin. The exterior plaster-work is on spruce lath, the first coat consisting of lime, hair and sand, the second coat of cement, lime and sand and the third coat of fine gravel and cement grout, colored buff with ochre and "cast in" while the second coat was wet. The gutters are 5-inch hanging gutters, as shown.

Fig. 286. Verge-Board Finish on Horizontal Eave-Soffit.

5. WATER-TABLES, CORNER-BOARDS AND BELT-COURSES.

185. WATER-TABLES. At the bottom of all wooden walls and just above the masonry walls there should be an offset or water-table to throw the water which runs down the walls away from the masonwork. Fig. 287 shows a section of water-table which is much used and which answers every purpose. The flashing shown is often omitted, as it is not necessary when the siding is tightly fitted to the board *b*.

Very often, when stone walls are used for the underpinning, the wooden sill is placed 3 or 4 inches in from the face of the wall, thus changing the amount of the projection of the water-table; but the construction is essentially the same. (See, also. Fig. 149.)

Fig. 287. Water-Table for Frame Building.

186. CORNER-BOARDS. When a wooden wall is covered with siding or clapboards, it is necessary to finish all the angles of the building with boards, put on vertically, against which the siding or clapboards may finish. These boards are called "corner-

boards," and when plain are usually from 4 to 5 inches wide at external angles, and 2 or 3 inches wide at internal angles. On

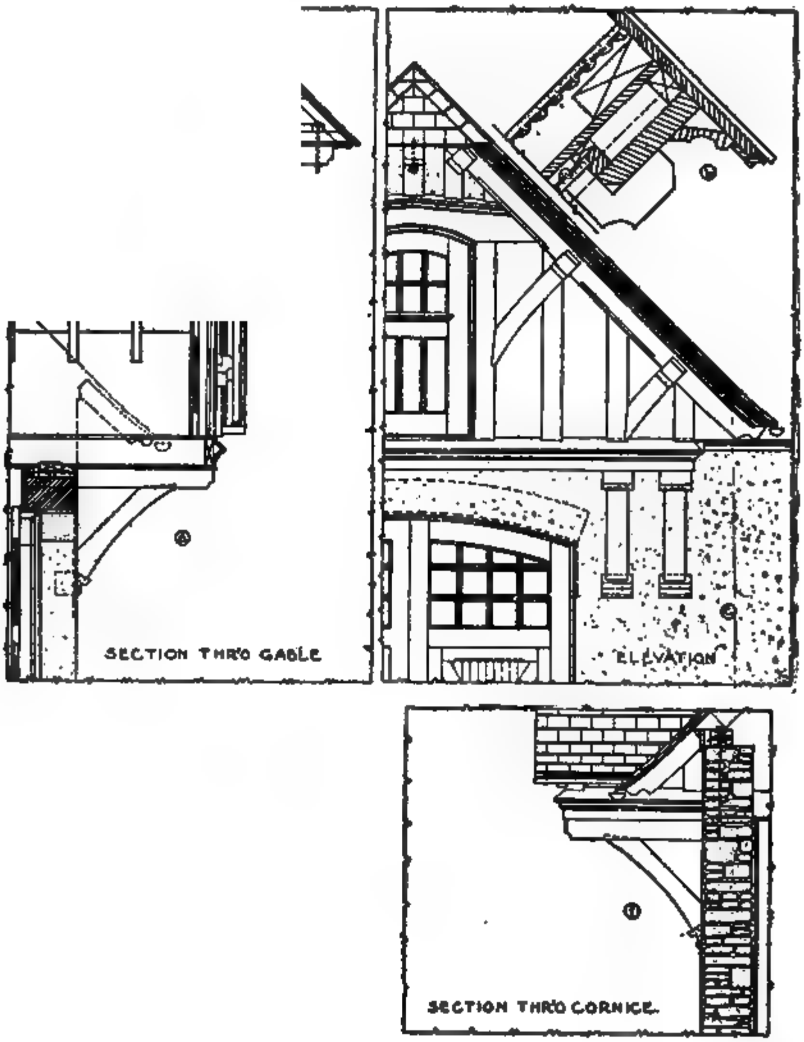


Fig. 288. Details of Gable over Stable Entrance, Merion, Pa.

"colonial" houses the corner-boards are frequently made in the shape of pilasters, from 10 inches to 18 inches wide and 1¾ inches thick. When the walls are shingled, corner-boards are not needed

and are, therefore, seldom, if ever, used. Sometimes the siding or clapboards are mitered at the corners and in this case corner-boards are omitted.

187 BELT-COURSES. Wooden belt-courses are frequently placed on the walls, or across the gable-ends of wooden buildings and occasionally on brick buildings. These courses are generally built up of thin stuff, as shown in Figs. 282 to 285, etc., nailed to forms or furring-blocks, which are nailed to the sheathing of frame houses, or to the bond-timbers or lookouts laid up in the walls of

Fig. 289. Types of Wooden Water-Tables.

brick houses. They are constructed in many forms to suit various designs, but the upper surface, when exposed, should always pitch outward so that water will run off freely, a good drip being provided at the outer edge. The point where the top surface joins the wall should be flashed with tin, lead, zinc or copper pieces, about 4 inches wide. Very often the entire top surface is covered with tin or zinc. On shingled walls the shingles are usually brought out over the belt-course, as in Fig. 285, in which case flashing is not required. Fig. 289 shows various types of belt-courses below shingling. Sections *b* and *c* are for frame walls above brick or stone walls and could be used either as belt-courses between stories or as water-tables. The details show the general methods of construction.

188. FALSE HALF-TIMBER WORK. Fig. 290 shows various details of "false" or "sham" half-timber construction. The timbers are usually from 4 to 12 inches in width, 1, 1¼, 1½ or 2 inches in thickness and are often left rough. The timbers project from ⅛ of an inch to 1 inch from the face of the plaster, which is usually applied on woven wire, metal lath or plaster-board. (See, also, Art. 193.)

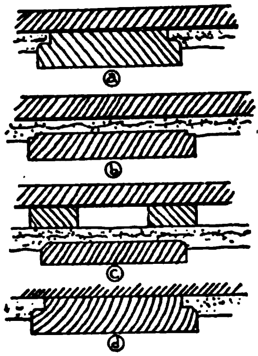


Fig. 290. Details of Sham, Half-Timber Construction.

6. COVERING OF OUTSIDE STUD-WALLS.

189. CLAPBOARDS. The walls of wooden buildings are usually covered with clapboards, siding or shingles. In most localities it costs less to cover a wall with siding or clapboards than with shingles and hence, when the cost is an important item, siding is generally used. When of good material and properly used, siding or clapboards make good and durable wall-coverings; and many persons prefer them to shingles.

"Clapboards," in the strict use of the term, are a peculiar product of the New England States, especially of Maine; and the author has never heard of their manufacture in other localities, unless it be in the Canadian provinces. The clapboards made in Maine are 4 feet long, 6 inches wide, ½ an inch thick at the butt and about ⅛ of an inch thick at the other edge, a cross-section resembling that of the beveled siding shown in Fig. 291.

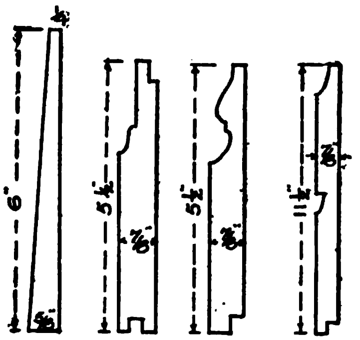


Fig. 291. Bevelled and Novelty or Drop-Siding.

These clapboards are cut from the log by a circular saw, which cuts from the circumference to the center, the log being hung as if in a lathe and revolved the proper distance every time the saw takes off a board. Every board being perfectly quarter-sawed, there is very little shrinkage or warping. When covering a building with clapboards the New England carpenters begin at the top and work down, as in this way the clapboards can be laid much faster and with much less expense in staging. Clapboards should be free from knots or sap and should be closely butted at the end-joints. The best Eastern

clapboards are made of white pine, although more clapboards are now made of spruce, and even hemlock clapboards are sometimes seen.

190. SIDING. Outside of the New England States "siding" is used instead of clapboards for wall-covering, and it is also coming into use in some portions of New England. The common siding has a section similar to that of clapboards, but is somewhat thicker. It is sawed from the log in the same manner as boards, in lengths of from 10 to 16 feet. The ordinary siding is not quarter-sawed.

Some of the advantages siding possesses over clapboards are the usually smaller waste in cutting, the avoidance of short splicing and the fewer joints. The common beveled siding is applied in the same way as clapboards, working from the top downward. The end joints should be carefully butted and for the best work the ends should be dipped in white lead and oil and should come over a stud. Six-inch siding or clapboards are usually laid with an exposure of 4½ inches to the weather. In some localities beveled siding is furnished in 4, 5 and 6-inch widths, but 6 inches is the ordinary width, the common section being that shown in Fig. 291.

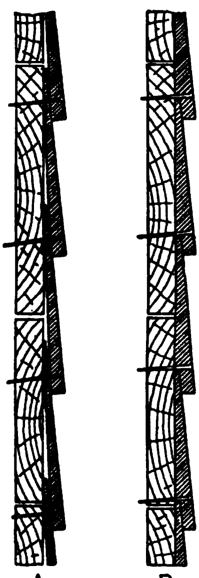


Fig. 292. Regular and Rebated Siding.

In Boston, and possibly elsewhere, a rebated siding, such as is shown at *B*, Fig. 292, is carried in stock. One advantage of rebated siding is that nails pass through only one piece of siding, and in case of shrinkage there is no danger of splitting as there is when the nails pass through two pieces, as shown at *A*. It is claimed, also, that rebated siding makes tighter joints, that it can be laid more rapidly and with greater accuracy; and that it lies close to the boarding, thus preventing any danger of splitting. The rebate is ⅝ of an inch deep, 5-inch siding showing 4⅜ inches to the weather.

Besides the beveled siding various styles of molded siding, usually called "drop siding" or "novelty siding," as shown in Fig. 291, are used. These are made from ⅞-inch boards and have only about ⅝ of an inch "lap" or "cover." Such siding could be "stuck" to order at a slight additional expense.

The most durable woods for siding or clapboards are cedar, cypress and redwood. Redwood is little used in the Middle Atlantic States as it decays too rapidly there. Next to these woods soft pine, Doug-

las fir, larch, or spruce make the best siding. The harder pines are too brittle for beveled siding, as they split in nailing. Clear spruce is very largely used, but is not as durable as the woods above mentioned. The best siding is quarter-sawed and there are generally first and second qualities, not quarter-sawed, the second quality usually containing more or less sap and in spruce a few small knots. Siding is often nailed directly to the studs, the sheathing or boarding, especially in the Western States, being omitted; but this should never be done except on summer-cottages. A building covered in this way is apt to be cold in winter and hot in summer and also much less rigid.

191. WALL-SHINGLING. Previous to about the year 1880 clapboards or siding appear to have been considered the only suitable coverings for the walls of frame buildings of any pretensions. With the advent of the modern country-house, however, shingles came rapidly into favor for covering the walls of dwellings and even of public buildings, when of frame, many dwellings being completely covered with shingles from sill to ridge.

The choice of shingles or siding for wall-covering is generally determined by the architectural design. As a rule, it costs a little more to shingle a wall than to cover it with beveled siding or clapboards, but the difference, usually, is not a very big item. Walls covered with shingles undoubtedly offer greater resistance to heat and cold than do those covered with clapboards, because when shingles are used there are usually three thicknesses at all points, while when siding is used there is practically but one thickness.

Another reason, aside from the requirements of design, why shingles have been so much in favor as a covering for country and suburban buildings is that they are particularly adapted to the absorption of oil or creosote stains, by means of which texture-effects are produced that are not possible with siding or clapboards.

The kinds of shingles used for wall-coverings are the same as those used on roofs (for a description of shingles see Art. 201), except that for the walls they are sometimes cut to form ornamental patterns. For ornamental work it is best to use "dimension-shingles," that is, shingles of a uniform width; but for plain work this is not necessary, and even where the butts of the shingles are cut to a wave-pattern, for example, random widths may be used. It is desirable, however, that the width of wall-shingles should not be greater than 8 nor less than 3½ inches.

The manner of applying shingles to a wall is the same as that used for a roof; but a greater exposure of the butt is permissible as wall-shingles are generally laid with an exposure of from 5 to 6 inches to the weather. In finishing external angles the shingles

are usually lapped over each other alternately, as shown in Fig. 283. At the sides of the window-frames the joints should be flashed with sheathing-paper, tin or zinc, as explained in Art. 140. (See, also, Arts. 201 and 202 for roof-shingling.)

192. SHEATHING-PAPERS, FELTS, QUILTS, Etc.* † It is well known that frame buildings when merely sheathed and clapboarded or shingled on the outside and simply lathed and plastered on the inside, are almost sure to be hot in summer and cold in winter; and as the wood almost always shrinks, cracks result through which the wind finds its way. For these reasons some extra provision should be made for keeping out the wind and the heat and cold; and it is generally admitted that there is no material that will do this so well and at so small an expense as good sheathing-papers or sheathing-felts. The papers made for this purpose are commonly known as "sheathing-papers" or "building papers." There is a great variety of sheathing-papers manufactured, many of them of great excellence, and even the best are comparatively inexpensive, costing only about $1.00 per 100 square feet; so that only the better qualities of any kind of felt or paper should be specified. Where the cost of the sheathing-paper on an ordinary house is only a few dollars, it is poor economy to use a cheap paper, as the labor of applying it is an important item and the poorer the paper the more difficult the work of putting it on.

The qualities which good sheathing-paper should possess are permanence, impenetrability to air and water and sufficient strength to permit of applying without tearing. Protection or proof against vermin and insects is another important requirement. It should

* The following, although necessarily restricted to a few lines, gives a general idea of the cost of different kinds and types of papers and felts, the prices being fair averages:

	Price Per 100 square feet.
Common tarred felts, (15 lbs. per square)	30 cents.
Red rosin-sized sheathing, best grades	25 "
Monahan's parchment sheathing, single-ply	26 "
" " " double-ply	40 "
" ship-rigging tar-sheathing, 2-ply	75 "
"Neponset" black (waterproof) paper	45 "
" red-rope roofing	$1.20
Sheathing-papers with asphalt center	40 to 50 cents.
Asbestos building or sheathing-felt, 10 lbs. per square	22½ "
" " " " " 14 lbs. per square	31½ "
Cabot's sheathing-quilt, single-ply	$1.05
" " " double-ply	$1.25
Barrett's specification-felt	35 cents.
Barrett's "defender," felt sheathing	80 "
Sackett's waterproof sheathing	30 "
Empire parchment-sheathing, 1-ply	25 "
" " " 2 "	36 "
" " " 3 "	50 "
Barrett's red rope	$1.00
" black, waterproof sheathing	40 cents.

† See, also, Arts. 216 to 220, Chap. V., and Art. 140, Chap. III.

not be brittle nor have a lasting strong odor and, for the convenience of the builder, should be clean for handling. There are so many papers possessing all or most of these qualities that it is deemed inexpedient to mention particular brands. The architect should decide for himself, from the samples with which he has probably been furnished, what papers are best adapted to the particular conditions; and he should then specify those brands, giving, also, the manufacturers' names, instead of leaving the choice to the builder, who will be quite sure to be guided by price rather than by quality. Many object to tarred or saturated sheathing-papers and felts because of their tendency to become brittle and because they emit a strong odor and are somewhat disagreeable to handle. On the other hand, the advocates of tarred felts emphasize their cheapness, warmth and even their odor, which makes them vermin-proof. The odor gradually disappears after the clapboards, siding or shingles are put on and the inside walls finished.

The common "rosin-sized" sheathing-paper, while wind-proof at first, is not moisture-proof, as the amount of rosin used in the sizing is almost a negligible quantity and, under many conditions, subject to decay.

Sheathing-paper is usually applied just previous to putting on the clapboards, siding or shingles. It is generally placed horizontally and should lap about 2 inches over each sheet and over the paper previously placed around the window and door-frames. If sheathing quilt or similar material is to be placed under the clapboards or siding, laths should be nailed vertically over it, opposite each stud, and the siding or clapboards nailed to the laths; otherwise it will be difficult to put them on evenly, owing to the thickness and elastic quality of the "quilt." Shingles, however, may be applied directly over it. Sheathing quilt possesses marked fire-resisting properties.

The sheathing-paper and the labor of putting it on should be included in the carpenter's specifications.

193. STUCCO FINISH ON OUTSIDE STUD-WALLS. Fig. 293 * shows a detailed horizontal section of an exterior wall with stucco-finish. The studs are placed 12 inches on centers and are bridged with 2 by 3-inch bridging inclined in alternate directions in adjacent spaces. The furring is made of ¼ or ½-inch painted or galvanized-steel rods or crimped strips. The painted, expanded-metal lath is fastened over the furring-strips with 1¼-inch, No. 14-gauge, galvanized-iron staples. After the outside lath has been back-plastered, the air-spaces are divided by applying heavy

* This drawing is reproduced by permission of The Associated Metal-Lath Manufacturers, Youngstown, Ohio.

building paper, quilting or other ventilating-material between the studs, and fastening it by nailing wood strips over the folded ends of the material. (See, also, Art. 188.)

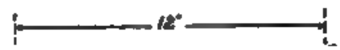


Fig. 293. Stucco-Finish on Outside Frame Walls.

194. JOINING OUTSIDE FRAME AND STONE WALLS. Suburban and country residences are often built with part of the walls of framework and part of stonework; and as the young architect may be puzzled as to just how these walls should be joined there is added an illustration (Fig. 294) of the method adopted in a house designed by Mr. Cass Gilbert.*

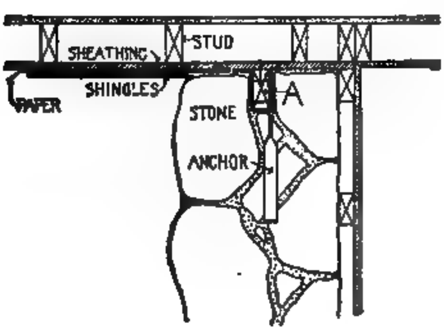


Fig. 294. Method of Joining Outside Frame to Stone Walls.

It should be noticed that the stud *A* forms an anchor to keep the wall in place, sidewise, and that the sheathing-paper on the wooden wall is extended around this stud and the joint between the stone and the paper filled with cement. The outer edge of this joint is made concave in order that the shingles may fit into it. The stud *A* should be anchored to the stone wall so that in case of settlement the two will not separate.

7. PORCHES AND PIAZZAS.

195. GENERAL CONSTRUCTION OF PORCHES AND PIAZZAS. The building of a porch involves two kinds of work,

* This illustration was first published in the "American Architect," on March 14, 1885.

the rough work, which supports the floor and roof, and the finished work, which is the part exposed to the eye.

The framing of porch-floors has been described in Art. 91. The rafters of the roof are supported by a plate or beam spanning from post to post or from post to wall and usually enclosed by the cornice or by a false beam built up of ⅞-inch boards. When the

A B

Fig. 295. Porch-Details. Classical Types. See Fig. 296.

finished posts are circular in cross-section they usually form the support for the roof; if the posts are square or rectangular in cross-section, a rough post is often set up to support the plate and a finished post built around it. Hollow, built-up, wooden posts should never be used to support any great weight.

Porches may be built and finished in so many different ways that it is impossible, in a book of this character, to consider more

than a few general features. The floor should rest on a solid foundation, brick or stone piers being the best, and all vertical wooden supports should be set with the fibers running vertically. All joints should be so made as not to be exposed to the weather and the various parts neatly joined and well nailed together. Porches built against brick or stone walls should have the upper part secured to the wall by ¾-inch bolts set in the wall as it is built.

196. FLOORING, STEPS AND LATTICE. 1. *Flooring.* Hard pine, such as shortleaf pine, or other suitable wood, should be used for the flooring. For first-class work the boards should be not over 4 inches wide, 1⅛ inches thick, quarter-sawed and free from knots or sap. In the Middle Atlantic States very little flooring is made over 3 inches wide. In regard to the use of matched flooring, custom varies in different parts of the country. In the New England States it is customary to lay porch-floors with open joints. The boards have square edges, are set about 3/16 of an inch apart and the nails are driven through the top. In other sections of the country matched flooring is generally used and blind-nailed in the joints. The author is inclined to favor the open-joint flooring, especially in localities where there is much rain or snow, although in climates like that of Colorado the tight flooring is perhaps more satisfactory. When the boards are matched they should have the tongue painted with thick, white lead and oil just before the boards are laid, and the floor should pitch from the wall outward about 1 inch in 6 or 8 feet to prevent the water from remaining on it.

When the porch is enclosed by a solid wall it is good practice to run a narrow strip around the outside edge of the flooring with a groove worked in and graded to form a gutter and with holes bored through to let out the water.

When the porch is open the floor-edges are finished with a "nosing" and "cove," as shown in Fig. 296. Very often the ends or sides of the floor-boards are rounded and the cove-molding placed underneath; with open floors this is the best construction. With tight floors a solid molding, nailed to the edge of the floor as in Fig. 296, presents a neater appearance on the face, but shows a long joint on the floor and is not as durable a construction as a nosing worked "on the solid."

2. *Steps.* The steps, if of wood, should be supported on plank strings, set from 16 to 20 inches apart and resting on a foundation-wall at the lower ends. The wall should extend below the frost-line. The treads should be 1¼ inches thick, with the front edges rounded to form a nosing and the ends, when open, finished with a nosing "planted on" and mitered at the corners. A cove-molding is usually placed under the nosing. The ends of the steps are gen-

erally finished with a triangular panel, the panel being solid or formed of lattice-work, according to its size.

3. *Lattice.* When built of wood the sides and front of the porch below the floor are generally finished with wide casings with

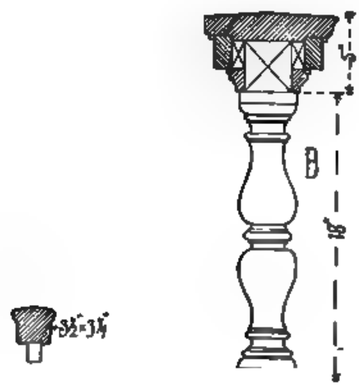


Fig. 296. Details of Porch "A," Fig. 295.

lattice-work in the panels. There are two methods of forming this lattice-work, the cheaper and more common one being shown at *A*, Fig. 295. In this construction lattice-strips of stock size, ¼ by 1⅛ inches, are nailed over each other, the vertical strips being on the outside. The strips should be so set that the openings will be square and equal to the width of the strips which are nailed to-

gether where they cross. In the other method strips ¾ of an inch thick and about 2½ inches wide, halved together at the intersections, are used, appearing as shown at *B*, Fig. 295. The latter style of lattice undoubtedly appears to be more substantial than the other, but it costs two or three times as much. In putting up the lattice it is customary to nail the strips to the rough work of the porch and then nail the casings over the strips; but it is better, with a porch like that shown at *A*, to frame the casings together and to nail the strips to the back of the frame thus formed, in order that it may be removed should occasion require.

197. SUPERSTRUCTURE OF PORCHES. 1. ***Posts and Columns.*** The style and construction of the porch-finish depends

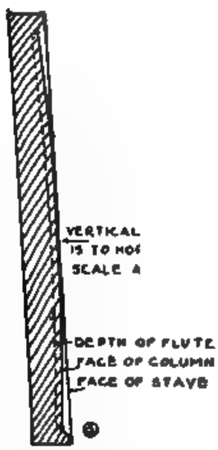
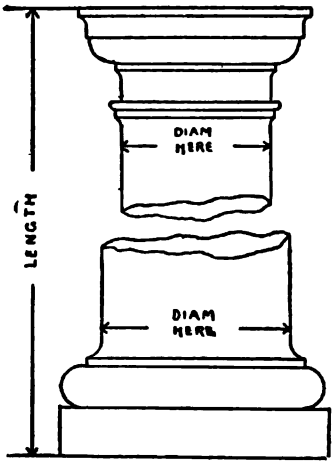


Fig. 297. Details of Staved-Up Wooden Column.

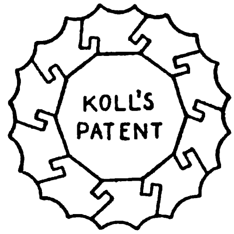
a great deal upon the architectural design. Porches of the so-called "colonial" or "classical" type usually have turned columns resting either on pedestals or on the floor, as shown in Fig. 295. When a post stands on a pedestal its diameter is decreased and consequently it can be turned from a smaller piece of wood. The decrease in the diameter also lessens the height of the cornice above, the proportions of the column and cornice being approximately those given by Vignola.

Unless made of staved-up pieces, posts less than 12 feet in height are almost always turned from a solid timber. Idaho white pine, cypress, fir and redwood are generally used for this purpose for exterior work, as these woods may be obtained in large pieces free from knots and as they "stand" well.

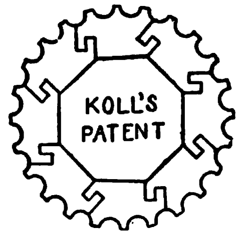
The caps and bases are commonly turned out of pieces of planks set with the grain horizontal. The smallest cross-dimension of the



Showing where measurements of columns should be taken.



Section showing Doric fluting.



Section showing fluting on all other Columns.

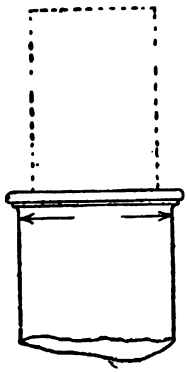


Fig. 1

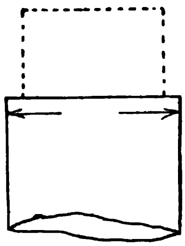


Fig. 2

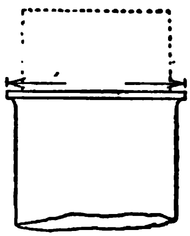
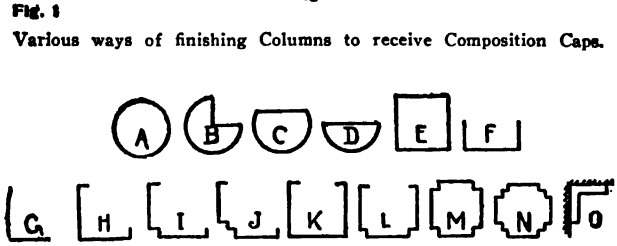


Fig. 3

Various ways of finishing Columns to receive Composition Caps.



Sections of Columns and Pilasters.

Fig. 298. Wooden Porch-Columns.

timber from which a post is turned should be greater than the lower diameter of the column, in order that the fillets at the top and bottom of the shaft may be turned on it. Solid columns will crack and check less if they are bored longitudinally through the axis. Fig. 297 shows at *b* a horizontal section through a staved-up

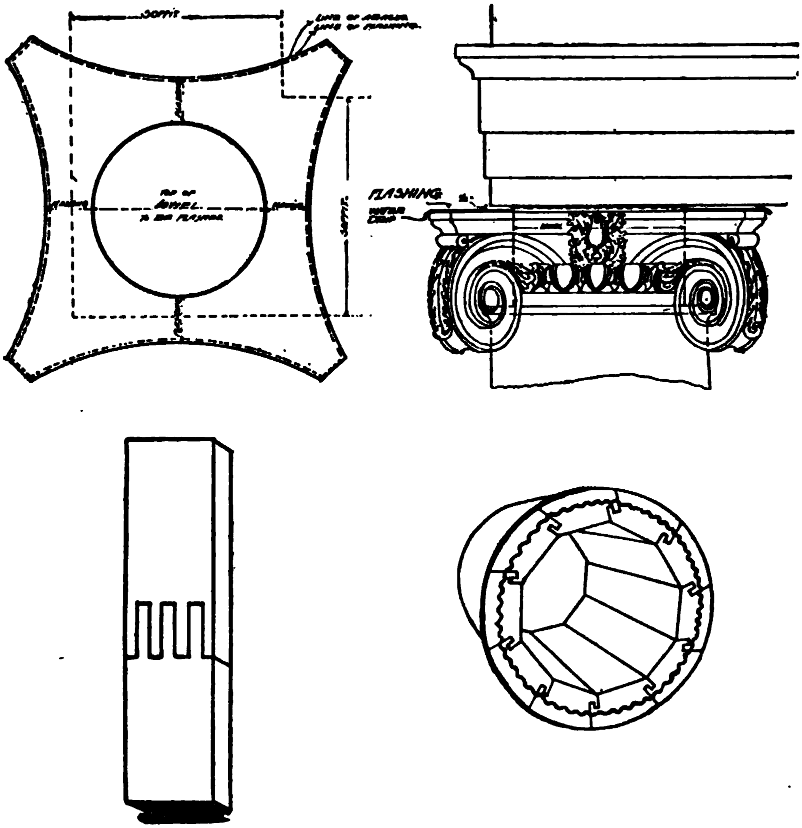


Fig. 299. Wooden Column-Cap, Shaft and Spliced Butt-Joint.

wooden column and at *a* a diagram indicating the method of setting staves so that the shaft may be turned with the "entasis" and the "apophyges" or "congés" at the top and bottom. The details show a column 22 inches in diameter staved up in twenty pieces. A column 12 inches in diameter would require but eight staves. All wooden columns, 12 inches or more in diameter, should be staved up in some approved manner as shown. White pine and other woods, 2, 2½ or 3 inches in thickness are commonly used. They should

be kiln-dried, glued and splined together; and the rough shaft should be tapered to avoid having it turned too thin at the upper end in giving it the entasis and to allow of the turning of the apophyges. The vertical joints in fluted, wooden columns may come anywhere with reference to the flutes themselves, but they should all be made perfectly tight. The horizontal section shown is taken through the thickest part of the wood. Flutes should not be so deep that they cut nearly through at the top and bottom of the shaft where the taper and inclination of staves make the flutes come close to the splines.

During recent years new and improved methods of making wood columns for both exterior and interior use have been introduced. These methods have resulted in various lock-joint, staved and turned columns, the methods of putting together being generally patented.

Figs. 298 and 299 show various details of Koll's patent, lock-joint, staved and turned columns.* The first drawing in Fig. 298 indicates what measurements are taken to determine all others. Care should be taken to specify that the fillets and curves at the top and bottom be turned as parts of the shaft. The cross-sections show the lock-joint of the staves, the upper section showing the channeling for the Greek and Roman-Doric shafts and the lower section showing the fluting for all others. The three drawings of the upper parts of the shaft show the various ways of turning the necks of the columns to receive composition caps, leaving a dowel shouldered on top of the shaft to carry the weight. The smaller sections show various plans or cross-sections of columns and pilasters. Fig. 299 shows the plan and elevation of an Ionic capital with the proper flashing indicated. The flashing, preferably of sheet lead or copper, should cover the top of the dowel and the top surface of the abacus, finishing in a drip over the fillet of same. If this flashing is omitted, water from the face of the entablature is apt to run into the cap and column-shaft and swell the wood. This figure shows, also, a spliced butt-joint, for splicing staves longitudinally in very long columns. The pieces are put together under screw-pressure, with hot glue. Fig. 299 shows, also, a perspective view of the lower end of a column-shaft of a Koll column, with a corrugated-steel band or ferrule-reinforcement set in to give additional strength. This is particularly efficient for the Greek-Doric columns which have no base. This reinforcement is usually added to both ends of these columns.

Wooden columns of this type are made up from different thicknesses of wood, the stock varying from 2 to 4 inches and the cost

* Manufactured by the Hartmann-Sanders Company, Chicago, Ill.

of a column varying with the amount as well as with the kind of lumber used. The stock for exterior columns is usually specified to be "free from large or loose knots, sap or shakes," while the stock for interior columns is specified to be "perfectly clear." For exterior work, the "standard" wood used is a specially selected grade of white pine. Columns of western fir cost about 10 per cent less. They can be furnished also of spruce, redwood or cypress at about the same price as that charged for white pine. For interior work, white pine, whitewood and gum are used for painted work; and cypress, yellow pine or any of the hardwoods for natural finish. Hardwood columns are made solid, staved up, or veneered on a softwood core. Staved-up columns are made with diameters varying from 6 to 54 inches and they can be made plain, fluted or channeled and, up to 35 feet in length, turned in a lathe. (See, also, Art. 289, Chap. V.)

2. *Rails and Balusters.* The rails and balusters are of varying sizes and shapes according to the design. Rails less than 4 by 4 inches in cross-section are usually "stuck" from a single piece of wood; when larger than this it is best to have them "built up." It is good practice to bevel the tops of both rails to prevent water from standing on them, the beveled top on the lower rail serving also to hold the balusters more securely. For residences not too pretentious in style, plain balusters, in section 1¼ inches square or ⅞ by 1¼ inches, when set about 1¼ inches apart, make relatively inexpensive railings or balustrades. The builders of the better colonial residences generally used balusters 4 or 5 inches in diameter and a correspondingly heavy rail, as shown at *B*, Fig. 296, and such balustrades are still used. They are, of course, much more expensive than those in the other railing shown. A common-size section for turned balusters for porch or piazza-railings is 1¾ inches. The usual height of the top of the rail from the floor is 2 feet 6 inches. The lower rail should be kept 2 inches above the floor to facilitate sweeping, blocks being placed under the rail at distances of 4 or 5 feet to keep it from sagging.

When short posts are used they are usually nailed to the flooring, and when they do not come at angles of the porch should be further strengthened by iron angles screwed to their sides and to the flooring.

3. *Cornices and Gutters.* The construction of the cornice of porches such as have been described, is illustrated by the enlarged section in Fig. 296. It should be noticed that the plate which supports the rafters is placed directly under them and is supported over the columns by uprights formed of studs. The lower plate is suspended from the upper one between the posts, but when the

facing pieces are put in place, the entablature is really self-supporting.

In designing residence-porches facing the south or west, a mistake is very often made in placing the bottom of the entablature so high above the floor that the roof does not furnish during the afternoon the proper protection from the sun. For porches thus situated, unless they are very deep, the clear opening above the floor should be not more than 8 feet. On the east side of the house this is not a matter of so much consequence.

It is always advisable to provide the porch-roof with gutters and conductors. When the roof is flat the gutter may be formed in the roof as shown in Fig. 296. A pitch of ⅜ of an inch to the foot is sufficient for a tin roof.

If there is a railing above a tin roof the best method of securing the railing-post, if square and built-up, is to extend from the plates,

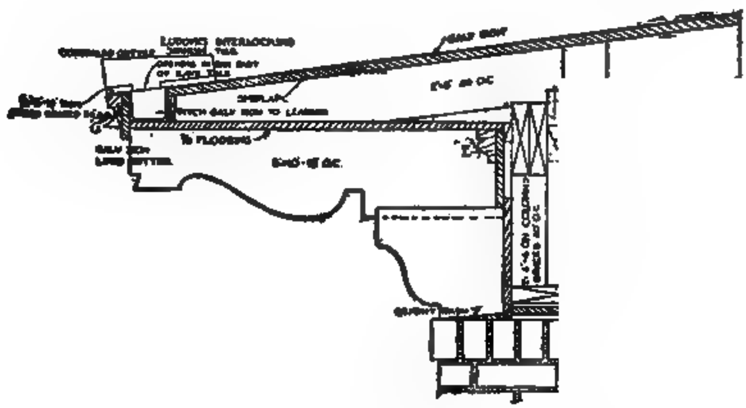


Fig. 300. Porch-Cornice of Residence, Seattle, Wash.

12 inches or more above the roof, rough scantlings and to turn the tin up around them, soldering it at the corners. The finished posts are then set over them and are securely held, and there is little danger of leaks appearing in the roof at the posts.

If turned railing-posts are to be used they may be extended through the roof in the same way and the top of the tin turned into saw-cuts made in them, the saw-cuts being then filled with putty; or blocks of wood about 1⅜ inches thick and 1 inch larger in cross-section than that of the posts may be nailed over the tin roof and covered with tin soldered to the roofing. The posts may then be toe-nailed to these blocks. Angle-posts are braced sufficiently by the railing without being extended through the roof; but when intermediate posts are used it is best to carry them to the plates.

Fig. 300 shows a section through the porch-cornice of a residence in Seattle, Wash., designed by Gould & Champney. The main cornice is shown in Fig. 266. The cornice rests on brick piers as shown, the doubled plates supporting the rafters resting on 4 by 4-inch pieces standing on the piers. The gutters are "concealed" and are formed at the end of the rafters, lined with galvanized iron and have openings in the pan-parts of the interlocking tiles at the eaves. Fig. 301 * shows the cornice-detail of a porch over the main entrance of the residence designed by Richard Arnold Fisher for Mr. A. C. Potter at Cambridge, Mass. The roof is covered with canvas and the railing is of wrought iron. The cypress gutter is fastened to the rafter-ends. The total height of entablature, from column-cap to edge of roof above gutter, is 2 feet 3½ inches; the total projection from frieze to outside of gutter, 1 foot 1½ inches; the upper diameter of column-shaft, 12 inches; and the lower diameter, 14½ inches. The posts of the iron railing are 1½ by 1½ inches; the upper rail, 1¾ inches by ⅝ of an inch; the lower rail, 1¼ inches by ½ of an inch; and the balusters ⅞ by ⅞ of an inch in cross-section.

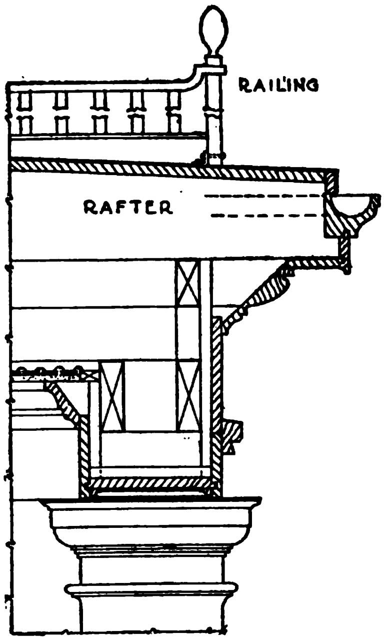


Fig. 301. Porch-Column, Cornice and Roof-Railing of Residence, Cambridge, Mass.

4. *Movable Floors for Balconies.* If the porch-roof is to be used as a balcony it should be covered with tin or copper and a movable flooring, made of slats and cleats, laid over it. The slats should be of 4-inch square-edged flooring-pieces, laid ¼ of an inch apart and nailed to 1⅜ or 1¾-inch cleats, which should be blocked up from the tin and not fastened to it in any way. This flooring should be made in sections of sizes convenient for handling.

5. *Hoods.* Fig. 302 * shows the details of a hood over an entrance-door of the residence designed by Charles Barton Keen for Dr. Marsden, at Chestnut Hill, Pa. The hood-roof is covered

* Figs. 301 and 302 were redrawn, by permission, from "Building Details." Frank M. Snyder.

with shingles and the gutters are tin-lined and formed with gutter-strips as shown.

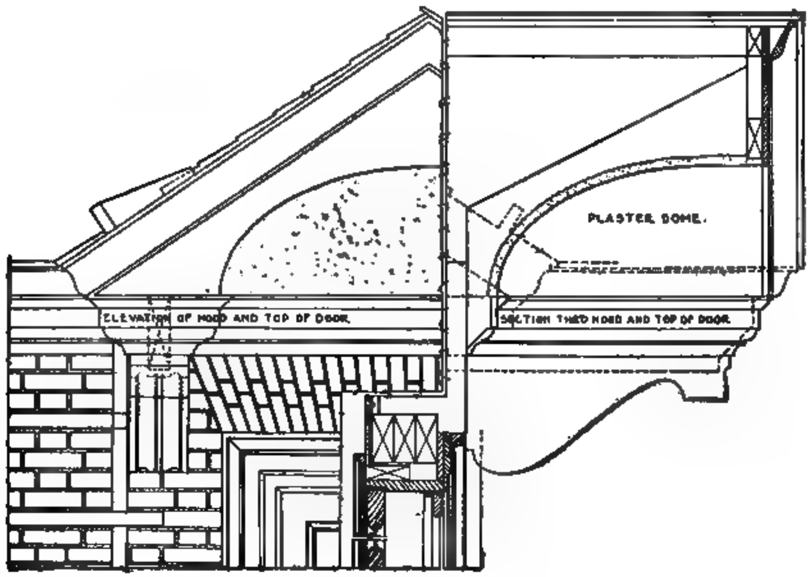


Fig. 302. Hood Over Entrance Door. Elevation and Section.

8. DORMERS.

198. GENERAL DESCRIPTION OF DORMERS. (See, also, Art. 129, Chap. II.) Dormers are of two kinds, those built entirely on the roof, as in Figs. 304 to 307 and those which form a continuation of the wall, as in Fig. 303. On isolated or suburban residences the former are more common, although on story-and-a-half houses the latter are often used. Dormers of the latter type are very common on the fronts of public buildings and city residences, but they are usu-

Fig. 303. Dormer Forming Continuation of Wall.

ally built either of masonry or metal and often with elaborate gables, pilasters, etc. There are so many different types of dormers and so many ways of roofing and finishing them, that it is impossible to give them more than a brief mention. As a rule, the eaves and roof are made to correspond with those of the building itself, except that when the eaves overhang the main roof there is no necessity for gutters.

To be of practical utility the window-sill should be not more than 2½ feet and the top of the window not less than 5½ feet above the floor.

A few examples of common types of dormers are shown in Figs.

Fig. 304. Gabled Dormer.

Fig. 305. Colonial Type of Dormer.

303 to 307. The simplest method of roofing a dormer, when the main roof rises high enough, is that shown in Fig. 303. The roof of the dormer should have a pitch of at least 30 degrees, and the outer edge should be provided with a gutter and conductor.

For dormers placed on the roof a gable or hip-roof has generally the best appearance and for these the style of finish shown in Fig. 304 is about the cheapest. On houses of the colonial type dormers similar to that shown in Fig. 305, or with a semicircular roof and gable, are often used; and frequently a single dormer of this type is placed between two of the type shown in Fig. 304. When the gable-end is semicircular the roof is generally of the same shape and covered with tin or copper; but when the gable is finished as in

Fig. 305, a pitched roof covered with slate or shingles is often used, the gable-cornice being made about 10 or 12 inches wide on top and covered with tin or copper, as shown at *T*, and the roof dropped behind it, as with masonry walls.

Figs. 306 and 307 show types of dormers often used on shingled houses. These admit of a great variety of treatment.

Fig. 306 illustrates a style of shingled valleys that has become quite common in this type of building. The valleys, instead of being formed as described in Art. 205, are rounded so that the

Fig. 306. Shingled Dormer and Valley. Fig. 307. Shingled Dormer with Hipped Roof.

courses of shingles may be made continuous from the main roof to the dormer. The juncture of the sides of the dormer with the main roof is sometimes shingled in a similar manner.

The framing of the sides and roof of all these dormers is very much the same, the description given in Art. 129 applying to nearly all wooden dormers. (See, also, Figs. 138 to 142.)

9. SKYLIGHTS AND SCUTTLES.

199. WOODEN SKYLIGHTS. Large skylights, and those having a gable or hip-roof, are much better if made of galvanized iron or copper than if made of wood, but small skylights or glazed

scuttles, when necessary for lighting attic-rooms, may be constructed of the latter material when not within the fire-district. A skylight of this kind usually consists of a glazed sash through which light is admitted, and the frame on which the sash rests and to which it is usually hinged.

When on a pitched roof, the skylight or sash is usually placed parallel with and about 8 inches above the roof. The proper method of constructing such a skylight is shown in section in Fig. 308. An opening is first framed in the roof by means of header and trimmer-rafters and the frame spiked to the inside of the opening. This frame should be made of 2 or 2½-inch planks, 11½ inches

Fig. 308. Wooden Skylight on Pitched Roof.

wide. The frame is often made of 6 or 8-inch rough planks nailed on top of the roof, the inside being flush with the rough opening and the opening and frame being cased with finished boards or ceiling. This method, however, is not as good as the one shown, as the wide planks add to the stiffness of the frame and opening and prevent the two from separating.

The sash is framed together in the same way as are window-sashes, but should have no cross-bars or muntins; and the lower rail should be made so that the glass will pass over it. The rails and stiles should be 2 inches wider than the thickness of the frame and a ⅞-inch strip should be nailed to the under side of the stiles, outside of the frame, to protect the joint. For economy in glass and also to stiffen the sash, the latter is usually divided into lights,

about 12 inches wide, by longitudinal muntins or sash-bars, as shown in the isometric view. The glass is usually set in putty at the top and sides, but at the bottom the upper side of the glass is left free to shed water. It is better, wherever possible, to use one light of glass between muntins. It is common practice today to use ¼-inch hammered glass in pieces as large as 30 by 60 inches. Where this is done, care should be taken to give the skylight a good slope, thus avoiding the dead weight of the glass which occurs where a light of this size is laid too flat. In case two or more pieces are used, as shown in the section, the lap should not be greater than from ½ to ¾ of an inch. Experience has shown that a wider lap than this causes a suction or lapping-up of the moisture of condensation. (See, also, Art. 160.)

Greenhouse roofs are glazed in this way, the divisions often being 8 or 10 feet long and glazed with small lights of glass. The thickness of the sashes should not be less than 1¾ inches, and if the frame-openings are greater than 3 by 4 feet the thickness should be increased.

The most important items in connection with a skylight of the type shown are the flashing and the provision for taking care of the condensation that always forms on the under side of the glass, if the room below is warmed or occupied.

Behind the top of the frame a gutter should be formed as shown, the board *B*, Fig. 308, being cut so as to be highest at the middle-point of the gutter and so as to fall to each side. The lining of this gutter should extend well up onto the roofing and should be turned over the upper edge of the frame into a groove which should be graded to drain off the water at the sides. If the sash is to open, it should be hinged at the top and a strip of lead nailed to the top rail to form a counterflashing, as shown at *H*. If the sash is stationary, a simple fillet may be nailed above the frame to the under side of the sash. The sides of the frame, like the sides of a chimney, should be flashed with tin or zinc, the flashings being carried to the top of the frame. At the bottom of the frame it is better to use a wide piece of galvanized iron for the flashing, as this will stay in place better than tin or zinc.

To take care of the water of condensation a small gutter should be formed in the flashing, as shown at *D*. As the water forms on the glass it runs down until it strikes the lower rail and then drops into the gutter. For a small skylight the water in the gutter will evaporate and not overflow; but on larger skylights provision should be made for draining off the water by means of a small pipe carried through the frame. On large skylights, also, if made of wood, the sash-bars should have a cross-section like that shown in the enlarged

section, gutters being formed at G to receive water that may run down on the sides of the bars. These gutters should empty into the gutter under the lower rail. Unless some such provision is made for receiving the water of condensation, much trouble will be experienced by water dripping on the floor.

The sash is usually fastened by a flat, iron bar, provided with holes to slip over a pin, serving either to secure the window or to hold it open at certain distances. The frame and sash should be made of clear, well-seasoned cypress, white pine or redwood.

When a skylight of the type described is placed on a flat roof,

Fig. 309. Detail for Large Wooden Skylight.

it may be constructed in the same manner, except that the frame should be made higher at one end than at the other, in order that the sash may have an inclination of about 2 inches to the foot. On flat roofs the frame or "curb" may be set on top of the roof.

Fig. 309 shows another detail, which, in some respects, is superior to the other for large skylights.

Fig. 310 * shows the details of one method employed for lighting the space under an entire roof when applied to a frame structure,

* Courtesy of The Kinnear Manufacturing Co., Columbus, Ohio.

In this case the skylight is continuous and may be composed of any number of sections. The detail shows the method of framing the

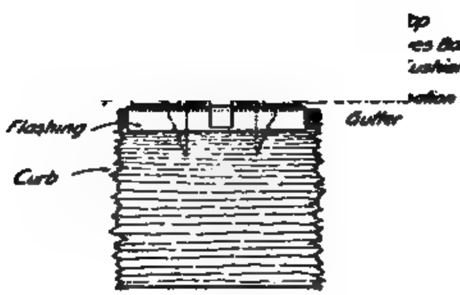


Fig. 310. Skylight on Frame Supports. Kinnear Details.

skylight into the wooden purlins. The smaller drawing shows a section at *A A*. Fig. 311 shows a larger detail of the system of glazing, method of securing glass, condensation gutters, etc.

200. SCUTTLES. Scuttles in a roof should be framed and flashed in the same manner as that described for skylights; and the cover should fit over the frame and be covered with tin or copper.

Fig. 311. Detail of Glazing in Fig. 310.

10. ROOFING.

201. SHINGLED ROOFS IN GENERAL. 1. *Woods used for Shingles.* Shingles have always been the common roofing-ma-

terial of the United States and probably will continue to be used for a number of years. While shingles are inflammable and not as durable as tiles or slates, the better qualities are sufficiently durable for the ordinary residence and if properly treated will not easily take fire. They are, also, admirably adapted to color-treatment by means of stains; and for this reason many architects prefer them to slate for residences. The low cost of shingle roofs heretofore, however, as compared with that of slate or tile roofs, has probably been the chief factor in determining the selection.

Shingles made from cypress, cedar, redwood, white and yellow pine and spruce, this being the order of their durability, are considered the best. Redwood shingles are much less inflammable than any of the others. Cypress and cedar shingles are about the same in price, cypress being slightly cheaper in some of the states. Cypress shingles are probably more durable than redwood shingles, but their advantage in durability is offset by the slow-burning qualities of redwood and also by its richer color, so that there is little choice between the two woods. Shingles are made also, in small quantities, from chestnut, hemlock, western pine and some other woods.

The most common woods actually used for shingles, however, are cypress, cedar and redwood. The cedar shingles are sufficiently durable when dipped in the proper kind of oil or stain. They are made largely from two species of cedar, the red cedar of the Northwest and the white cedar of the Lake States. Some white-cedar shingles are packed in bunches containing fifty shingles each, twenty bunches to the thousand, and are in 4, 4½, 5, 5½ and 6-inch widths, with those of each width bunched separately and stenciled to show the grade and width. This results in a percentage of gain in count when compared with those which are packed in varying widths. Some white-cedar, machine-dressed shingles require no paint or preservative to prolong their lasting-qualities. When unpainted, they turn to a beautiful silver-gray from exposure to the weather. The old-fashioned split-pine shingles were very durable, but the pine shingles now sold are inferior to those of cedar. Spruce shingles, also, are sold in some localities, but are not suitable for good work. Pine shingles are now little used in the Middle Atlantic States.

Practically all of the shingles now used have rough surfaces, just as they come from the saw.

2. *Sizes of Shingles.* Cedar and redwood shingles as commonly sawed are 20 inches in length, and cypress shingles usually 20 and 24 inches long, the longer ones allowing a greater exposure to the weather. Redwood shingles and the cedar shingles from the States of Washington and Oregon, which States furnish most of

the shingles used west of the Mississippi are 8/16 and 9/16 of an inch thick at the butt; cypress shingles are usually sawed thicker. Those used in Boston are 9/16 of an inch thick.

Ordinary roofing-shingles are of random widths, varying from 2½ to 14 and sometimes 16 inches. They are put up in bundles, usually four bundles to the thousand. A "thousand" common shingles means the equivalent of one thousand shingles, each 4 inches wide. This applies generally, but in many eastern cities dimension-sizes are much used.

When shingles are to be laid to form a pattern, it is advisable and often necessary to have them all of the same width. For this purpose shingles of certain widths are bunched together and sold as "dimension-shingles." The most common width for dimension-shingles is 6 inches, although in many localities 4-inch and 5-inch shingles are carried in stock. Dimension-shingles are generally of the best quality and are somewhat more expensive than those of random widths. In most cities dimension-shingles with the butts sawed to various patterns are carried in stock. Any suitable pattern, however, can be sawed from dimension-shingles at a small expense.

3. *Grading of Shingles.* Shingles are variously graded and marked by the manufacturers, the grades and marks differing for the different woods and in different localities.

Shingles of the best quality should be free from sap, shakes and knots. The Washington and Oregon cedar is almost entirely free from all these defects. In pine and cypress shingles small, sound knots are permitted when not nearer than 8 inches to the butt-end. Unless the architect is familiar with the markings of the shingles in the local market, it is best to specify "the best quality," rather than the "first quality," as the terms are not synonymous, the best quality being often marked "extra" or "prime," while "first quality" may really be used to designate a quality which is not as good.

4. *Durability of Shingles.* In regard to the durability of shingles, an instance is on record of cypress shingles which remained for one hundred and four years in a good state of preservation on the roof of a Virginia mansion. Redwood shingles should remain in good condition for from twenty-five to fifty years, and if dipped in oil they will probably last still longer. Cedar shingles should last, with ordinary treatment, from twelve to fifteen years; and if dipped in oil or creosote they should last twenty-five years.

5. *Paper Lining for Shingled Roofs.* The roofs of all buildings that are to be plastered (at least those in the Northern States) should be covered, under the shingles, with a layer of good, strong, water-proof paper. It is true that such a lining, by causing the shingles to sweat and rot on the under side, is apt to diminish their

durability unless they are dipped all over; but in the Northern States this disadvantage is more than offset by the additional warmth obtained, and by the prevention of the fine snow that sometimes sifts in under the shingles, from going any farther. Tarred felt has been much used for this purpose and answers very well, but there are water-proof papers which are more durable, cleaner and pleasanter to handle.

202. LAYING THE SHINGLES. Shingles are generally put on by the carpenter, although in the larger cities there are persons who make a specialty of shingling roofs; but it is doubtful whether, as a rule, they do the work as well as a regular carpenter could do it. The men who put on the shingles usually do all flashing also, except counterflashing, the flashing-material being ordinarily furnished by the tinner.

In shingling a roof the workmen always commence at the eaves, or lowest edge, and lay the shingles in courses, either to a line or straight-edge. The first or lowest course should always be a double or triple one, usually double, while the other courses are laid single. Each shingle should be secured by two threepenny nails, driven in about 8 inches from the butt; and if a very durable roof is desired galvanized nails should be used. Cedar, cypress or redwood shingles will usually remain in good condition long after the nails have been destroyed by rust.

The courses of shingles should overlap each other sufficiently to allow an exposure to the weather of a little less than one-third the length of the shingle. Unless the roof is very steep, shingles which are not over 16 or 18 inches in length should be laid not more than 4½ and 5½ inches, respectively, "to the weather." Of course, the more the shingles are laid to the weather the greater the area a thousand shingles will cover; and it is to the contractor's advantage, therefore, to lay them as much to the weather as he thinks safe. For this reason the specifications should always state how much of the shingle is to be exposed.

The following table shows the areas that 1,000 shingles, 4 inches in width, will cover when laid with different exposures, allowing nothing for waste.

The table gives the number and weight of cedar and pine shingles per square of one hundred square feet. The first column of the table gives the length, the second column the assumed width, the third column the "weather" or "gage," the fourth column the number of shingles per square, the fifth and sixth columns the weight per square of cedar and pine shingles, the seventh column the number of nails required per square, and the last column the weight of the nails per square in pounds.

TABLE VIII.

NUMBER AND WEIGHT OF CEDAR AND PINE SHINGLES PER SQUARE OF ONE HUNDRED SQUARE FEET.

Length, inches.	Assumed width, inches.	Weather or gage, inches.	Shingles per square of 100 sq. ft., number.	Weight per square of 100 sq. ft.		Nails per square, number.	Weight of nails per square, pounds.
				Cedar, pounds.	Pine, pounds.		
14	4	4	900	210	233	1,800	4.50
15	4	4½	800	200	222	1,600	4.00
16	4	5	720	192	213	1,440	3.60
18	4	5½	655	197	218	1,310	3.28
20	4	6	600	200	222	1,200	3.00
22	4	6½	554	203	226	1,108	2.77
24	4	7	515	206	229	1,030	2.58

This table, of course, applies to either walls or roofs. For hip-roofs 5 per cent should be added to the quantities in the table to allow for cutting; and for irregular roofs with dormer-windows, 10 per cent should be added.

The shingles in the different courses should be laid so as to break joint at least 1 inch and as much more as possible. They should

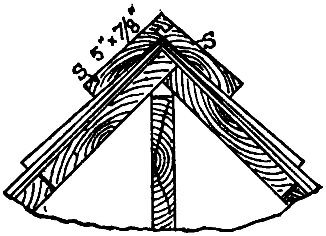


Fig. 312. Detail of Wooden Ridge, Showing Saddle-Boards.

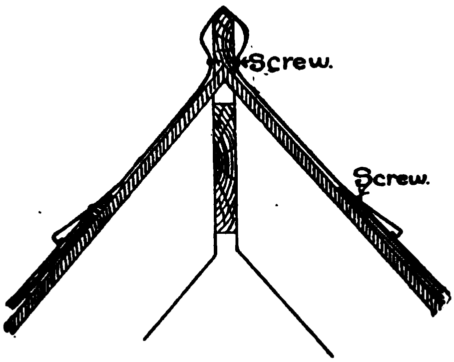


Fig. 313. Metal Ridge-Cresting.

not be laid too tightly together, for when they are laid in that way they will bulge when wet. (See, also, Art. 191.)

203. RIDGES AND HIPS FOR SHINGLED ROOFS. 1. *Ridges.* The ridge of a shingle roof is commonly finished by sawing off the tops of the shingles and nailing over them two boards, called "saddle-boards," as shown in Fig. 307 and in section in Fig. 312. If an ornamental cresting is desired it may be sawed out of a plank, set on edge, with the bottom edge formed to be set over the saddle-boards. In large cities it is a common custom to finish

the ridge of suburban dwellings with a galvanized-iron cresting, as shown in Fig. 313.

Fig. 314 shows various types of wooden ridges. Type *a* is a very cheap construction and is without ridge-pole and flashing. Type *c* is very similar, except that there is a pole and the saddle-boards are blocked up and flashed over, the flashing being turned under the shingles and secured to the boarding. Type *b* has heavy saddle-boards and pole and a wooden rod planted on top for effect. The flashing is similar to type *c* and extends under the rod in a continu-

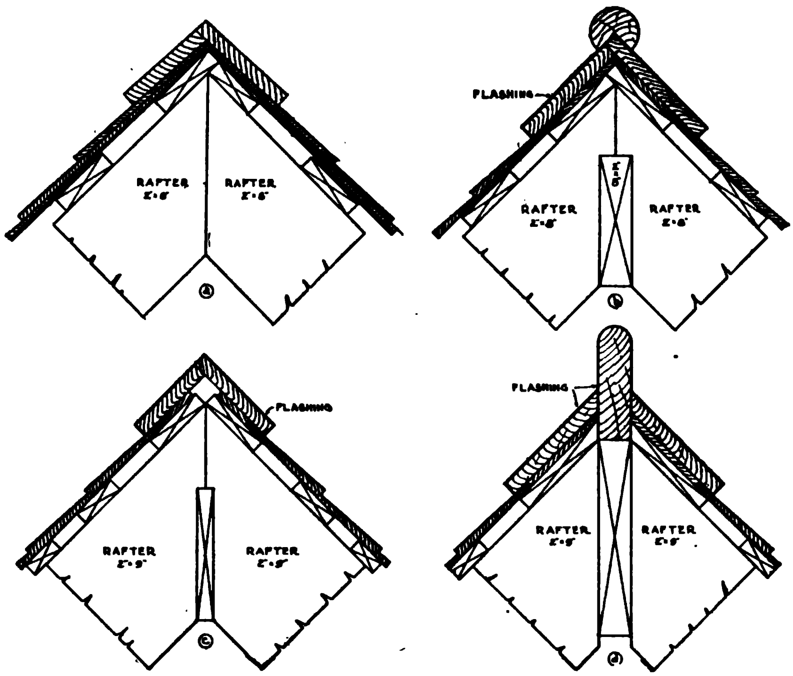


Fig. 314. Various Types of Ordinary Wooden Ridges.

ous piece. Type *d* has heavy saddle-boards, ridge and pole, the flashing continuing over the ridge and fastening to the boarding, as in *b* and *c*.

2. *Hips.* The hips of a shingle roof may be finished in any one of three ways: (1), by means of a wooden or metal hip-roll; (2), by close shingling and flashing; and (3), by shingling parallel with the hips.

In the first method wide shingles are selected for the hips to the

slant of which they are cut, a wooden molding of the form shown in Fig. 315, or a metal hip-roll, of the form shown in Fig. 316, being set over the joint. Wooden hip-rolls may be worked out of 1¾ or 2¼-inch stock. They are often turned in ornamental patterns to represent tiles. When galvanized-iron or copper hip-rolls are used it is best to nail a wooden hip-pole to the roof, under the metal roll, which is nailed to the former. In many cases, however, this wood

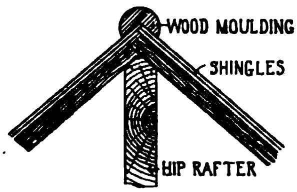


Fig. 315. Wooden Hip-Roll for Shingled Roof.

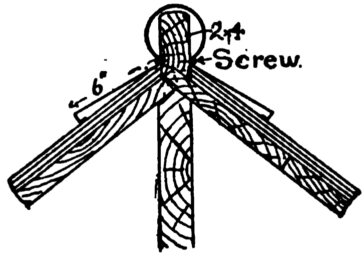
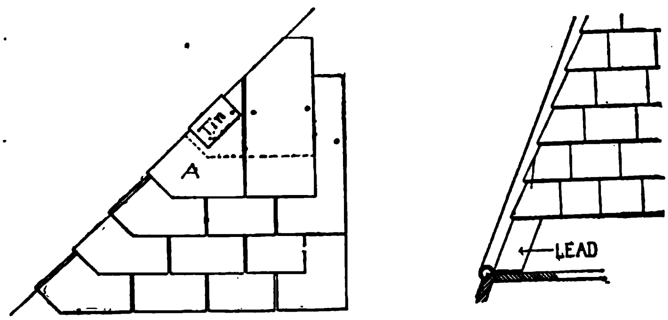


Fig. 316. Metal Hip-Roll for Shingled Roof.

piece is omitted, the metal being simply nailed to the roof through its flanges.

In making a close hip, wide shingles should be selected and cut to a pattern, as shown at *A*, Fig. 317, and over each pair of hip-



A B

Fig. 317. Types of "Close" Hips for Shingled Roofs.

shingles a piece of tin or zinc, 5 by 5 inches, bent to the proper angle, should be nailed, so that it will come just above the bottom of the next shingle above. This tin makes the hip tight and prevents the shingles from splitting and being blown off. The edges of the hip-shingles should be lapped alternately over each other

as shown, thus making the hip weather-proof. On very steep roofs the shingles, instead of being cut at right-angles to the hip, may have the butts carried out straight and the tin shingles may be used as above described.

A modification of this method, sometimes adopted, especially on spires, consists in forming the hips with 1¼-inch wood beads, nailed to the boarding on the lines of the hips and covered with long strips of tin or sheet lead, 10 inches wide, turned over the bead and spread out on the roof, as at *B*. The edges of the shingles are lapped over the flashing and laid close against the 1¼-inch bead. When care is taken to have the beads perfectly straight the result is a good hip-construction.

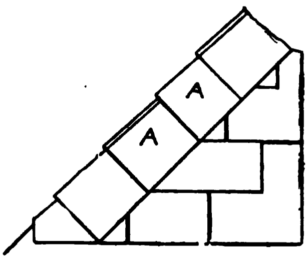


Fig. 318. "Boston" Type of Hip for Shingled Roof.

The third and cheapest method, sometimes called the "Boston-hip" construction, consists in laying a course of 4 or 5-inch shingles parallel with the hip and over the other shingles, as shown in Fig. 318, the hip-shingles lapping each other alternately, as shown at *AA*.

The hips and ridges of a roof are not very apt to leak, but unless the shingles are well secured they are liable to be blown off. It is easier to make the hips "straight" by means of a hip-roll than by the other method.

204. DECK-MOLDINGS FOR SHINGLED ROOFS. When a shingle roof terminates under a deck roof, covered with tin or copper, the best method of finishing the edge of the deck roof is by means of a galvanized-iron or copper molding, extending onto the shingle roof as shown in Fig. 319, the tin or copper roofing being locked and soldered to the top of the molding. A wooden crown-molding may be used in place of the metal molding, the roofing extending over the top; but the metal mold is much to be preferred.

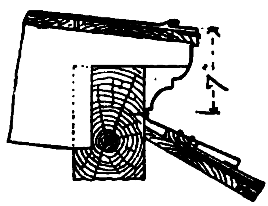


Fig. 319. Metal Deck-Molding.

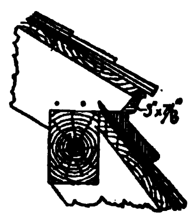


Fig. 320. Detail of Finish, Angle of Gambrel Roof.

If a railing or cresting of any kind is to be put around the edge of a deck or tinned roof, it may be secured to the roof in the following manner: Blocks of wood of the proper size to receive the

uprights are nailed *over* the tin or copper roofing to which they are soldered after being themselves covered with tin or copper. The uprights may then be screwed to these wooden blocks by brass screws.

The angle formed by the two slopes of a gambrel roof is generally finished with a molding as shown in Fig. 320, a small molding being used as the joint is intended to be inconspicuous.

205. FLASHINGS FOR SHINGLED ROOFS. 1. *Flashings in General.* If a good quality of shingles is used and ordinary care exercised in laying them, there should be no danger of leaks in roofs of ordinary slope. Leaks are most frequent in the joints around chimneys, dormers or skylights and in valleys, and special care should be taken to avoid them in the finished work. The only way in which these places can be made tight is by the use of "flashings," that is, pieces of sheet tin, zinc, copper or lead.

All tinwork, including flashings, should be done by a competent metalworker.

For shingled roofs tin of the very best quality or 14-ounce zinc should be used for flashings and 3 or 4-pound sheet lead for counter-flashings, although high-grade tin is often used for the latter also. Wherever tin is used, the flashings should be turned up to the proper shape, well painted on both sides and allowed to become thoroughly dry before using.

The use of zinc for flashings appears to be confined to the Eastern States, where it is considered by some superior to tin and often used. The roofers in the Rocky Mountain States claim that in the rain-water of those states there is a certain amount of alkali which eats away zinc but does not affect tin. Whether this is true or not the author does not know, but no zinc is used there for flashings and, in general, tin appears to be the common flashing-material throughout the country. One of the best stamped brands of tin should be specified, and it will be more durable if painted on the under side before using.

For slate roofs 16-ounce copper should be used, as it is much more durable than tin or zinc. For shingle roofs it is not generally used. For all counterflashings built or let into masonwork, sheet lead should be specified. For open valleys on large roofs the author has often used galvanized iron, frequently bent to the form shown in Fig. 321, the small ridge in the middle being made to prevent nails from being driven through the iron by the workmen walking in the valley. Tin valleys are often punctured in this way. It has been the experience of many, however, that galvanized iron is unsatisfactory for valleys or gutters, owing to the difficulty of keeping the seams or joints tight. The soldered seams in this metal split

open more easily than they do in any other. This is true, also, of copper, although it is possible to make copper seams more secure than those of galvanized iron. Some prefer, therefore, for work of this nature, a high grade of tin plate.

Fig. 321. Section of Open Valley.

2. *Flashing of Valleys.* For forming valleys there are two methods in common use. One method, generally used with shingle roofs, consists in lining the valley with long strips of tin or zinc, laid through its whole length and locked and soldered together at the joints. This lining is then nailed at the edges to the roof-boarding, about every 12 inches and the shingles are laid over its edges from 4 to 6 inches, leaving an "open valley" 6 or 8 inches wide, as as *A*, Fig. 322. On roofs having a pitch of 45 degrees or more the lining should be at least 18 inches wide, and on roofs of less pitch, at least 20 inches wide.

The second method is used for what is known as a "close valley" or "closed valley." Trapezoidal pieces of tin or zinc are cut out, usually 15 inches at the top, 10 inches at the bottom and 9 inches

Fig. 322. Open and Closed Valleys.

long for 16-inch shingles, and shingled into each of the courses. These flashing-pieces are bent in the middle and extend up on each side of the valley-angle to which the shingles are laid close, so that, when completed, it appears as shown at *B*, Fig. 322. Close valleys are generally preferred in the best work because of their more pleasing appearance and on steep roofs they can be made tight; but open valleys are more commonly used for shingle roofs of ordinary buildings and when the pitch is less than 45 degrees they are considered less likely to leak. From a constructional point of view and aside from the question of appearance, closed valleys are condemned by some first-class roofers, because particles of dust and dirt lodge in the joints and retain moisture. There is very little

opportunity for valleys of this type to dry out, and the flashings consequently rust through in a few years causing trouble and entailing considerable expense for their renewal.

The flashing against wooden dormers or any wooden wall should be done by working "tin shingles," about 7 inches square, into each course. These "shingles" should be bent in the middle to form a right angle so that one-half can be worked under the shingles on the roof and the other half under the shingles or siding on the wall, thus forming a sort of valley. If the pitch of the roof is less than 45 degrees the flashing should extend at least 4 inches onto the roof.*

The best method of flashing under the dormer-window sills, where leaks are likely to occur, was explained in Art. 129.

3. *Flashing against Brickwork and Stonework.* Flashings against chimneys, or where a roof abuts against a brick or stone wall, are put on in the same way they are placed against wooden walls, except that the flashings should be not less than 7 inches wide and should be covered by "counterflashings."

These counterflashings consist of pieces of metal, preferably 3 or 4-pound sheet lead, wedged or built into the joints of the masonwork and turned down *over* the flashings. They should be placed at least 6 inches above the roof, and in places where snow is likely to lodge, correspondingly higher. It is much better to build the counterflashings into the joints of the masonwork as the latter is laid, as they are then more securely held and as tighter joints can be made. When they are not built in, the joints should be raked out and the counterflashings inserted and wedged with metal, the joints being tightly pointed with elastic cement. The bottom of the counterflashings should be not more than 1 inch above the roof.

Fig. 323 shows flashing against a brick wall and into the "raggle-block." † The flashing is calked with oakum and cement into the groove in the block. It is claimed that no counterflashing is required with this construction.

Behind the chimney a "cricket" or "saddle" should be built and covered with metal to prevent snow and water from lodging there. Fig 324 shows a portion of a chimney flashed according to the method above described, which is the same for either shingles or slates.

At the back of towers, or in place where snow is apt to remain,

* The common size of tin shingles for flashing is 5 by 7 inches, the shingles being laid lengthwise on the roof and turned up 2½ inches. This is the smallest size that should be used; and in exposed places or on rather flat roofs they should be larger, about 7 by 10 inches, for example, so that they may be cut without waste from a sheet of 20 by 28-inch tin.

† Manufactured by the Campfield Raggle Block Company, Richmond, Ind.

the flashings should be carried high enough on both the roof and the walls to prevent the water from the melting snow from rising above it. The joints should be locked and soldered as in the flashing of an open valley.

Where a shingle roof comes against a stone or brick, gable-wall, finished with a stone or terra-cotta coping, the bottom of the coping should be kept at least 4 inches above the shingles and the

SECTION

Fig. 323. Flashing Against Brick Wall Into Raggle-Block.

flashings should extend to within ½ an inch of the coping. The counterflashing should be laid in the joint before the coping is set and the coping should project over it.

Where there is a large stone, such as a "kneeler," or "finial," a groove should be cut in the back of the stone, on a line with the bottom of the coping and the counterflashing wedged into the groove and pointed with elastic cement. Such places on large roofs are frequently a source of trouble and the flashing and counterflashing should be done with the greatest care.

The curbs of skylights and all parts rising from or coming against a roof should be carefully flashed. If the young architect wishes to establish a reputation for tight roofs he must be very particular

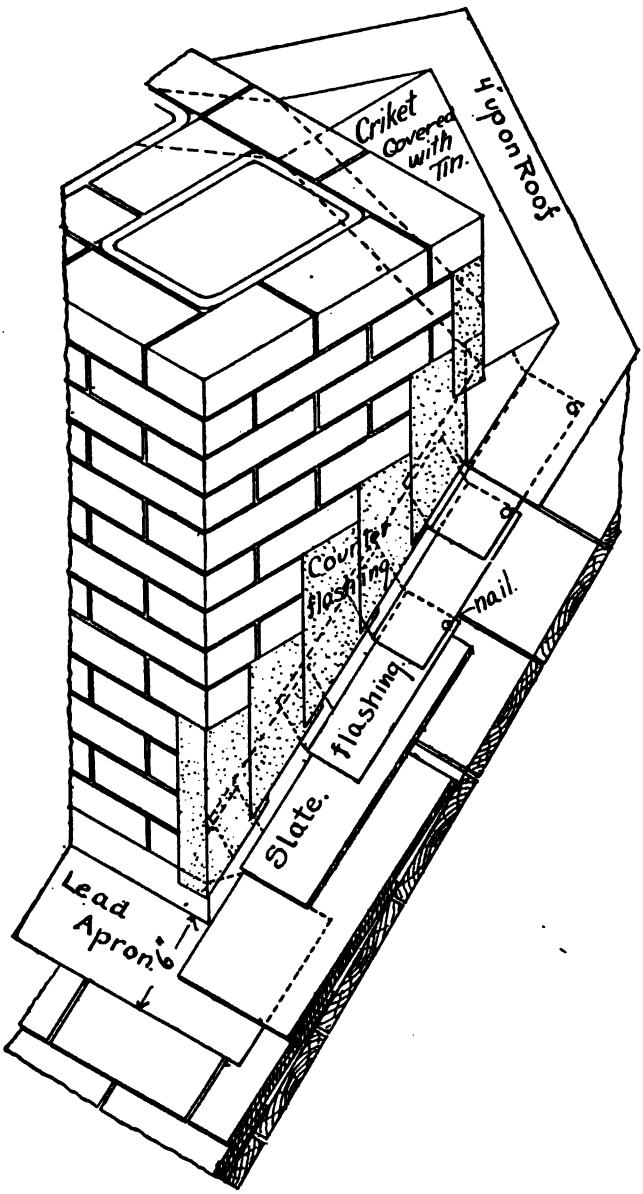


Fig. 324. Chimney-Flashing and Counterflashing.

to specify suitable flashing and counter-flashing, of ample width, as the builder will not be likely to put in more than is required. (See, also, Art. 140.)

206. SNOW-GUARDS FOR ROOFS. Snow-guards are small obstructions used on pitched roofs and usually made of copper or galvanized-steel wire. They may be placed over the entire roof or over a part of it to hold the snow where it falls, allowing no portion of it to move. The whole mass of snow is thus held in place until it is melted by the sun or the heat of the building and carried off as water through the usual channels. Besides diminishing the danger to passers-by from sliding snow, it prevents the snow from banking

Fig. 325. The Folsom Snow-Guard. Fig. 326. The Gilman Snow-Guard.

up at the eaves where it sometimes forms a pocket or dam into which the water runs and flows back under the slate or other roof-covering and damages the interior of the building. Fig. 325 shows the snow-guards made by the Folsom Snow Guard Company, of Boston, Mass., and applied to a slate roof.

The following is a table for the use of these snow-guards:

TABLE IX.

Number of Snow-Guards Per Square for Different Roof-Pitches.

Pitch of roof.	Number of snow-guards required per square.	
	New roof.	Old roof.
One-quarter	50	75
One-third	75	125
One-half	150	250
Gothic	One in every joint.	One in every joint.

In applying these snow-guards the undereaves course of slate is laid in the usual way; but in laying the overeaves course, the joints between the slates are left open in order to leave room for the shanks or body-parts of the guards. The next course is then lined out; but before it is laid the guards are put in by placing the snow-stop or loop-part of the guard just below the line, with the prong, or drive-point, in the joint between the two slates, and by driving it into the roof. The course of slate is then laid. The guards are applied in the other courses in the same way.

There are other types and forms of snow-guards for roofs on the market. Fig. 326 shows the Gilman snow-guard made by the U. T. Hungerford Brass and Copper Company of Philadelphia, Pa. The drawing shows the guards in place on the roof and also a larger detail of the end and side view.

207. TIN ROOFS. 1. *Preparation, Sheathing-paper, Brands.* It was not the purpose of the author in this book to describe methods of roofing with any materials other than shingles, as he proposed to treat the subject, which is an important one, in another volume; but as porch-roofs are very commonly covered with tin, it was decided that a short description of such roofs would be serviceable here.

Before applying the tin all uneven edges of the boarding should be smoothed off and the boarding covered with at least one thickness of sheathing-paper or dry, not tarred, felt, more to form a cushion than for any other purpose. If there are knot-holes in the boarding they should be covered with pieces of heavy, galvanized iron. The tin should be of one of the best brands and only those which have the trade-mark stamped on each sheet should be used. The under side of the tin should be painted before it is laid.

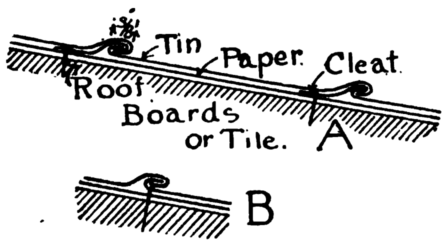


Fig. 327. "Flat-Seam" Tin Roofing.

2. *Laying Tin Roofs.* When tin is laid on a flat roof it is customary to use "flat seams"; that is, the four edges of the tin sheets are turned over so as to lock together, as shown in Fig. 327. After fastening the tin to the boarding, the seams are pounded flat and soldered, thus making one large sheet of tin covering the roof. Occasionally a double-lock seam is used, but for ordinary purposes the single lock shown is sufficient. The tin is usually laid in courses across the roof, using 14 by 20 or 20 by 28-inch sheets. The side seams are made first and the next

course is locked to the one below it. Each course should be fastened to the roof at the top, a common method of fastening being to nail the sheets to the roof by short, wire nails driven under the turned-over edge of the tin, as shown at *B*.

This method of fastening, however, is objectionable, as it causes the tin to form in waves as it expands and there is also some danger that the tin, in expanding, will draw the nails. A better method of fastening the sheets to the roof is by means of strips of tin, about 1½ by 4 inches, called "cleats." These cleats are locked over the upper edge of the sheets at intervals of about 8 inches and then nailed to the roof, as shown at *A;* when the next sheet above is laid, the cleat is concealed. These cleats permit the roofing to expand and rise somewhat without stressing the tin or drawing the nails and they are recommended for good work.

After all the sheets are laid the seams are pounded down with a wooden mallet and all the joints well soldered. For soldering, rosin only should be used as a flux, as acid, which is easier to use, is liable to destroy the tin. Before the roof is painted all rosin should be wiped or scraped off.

For large roofs, provision for expansion should be made by the use of "standing seams." To apply standing-seam roofing, the sheets are first locked together in the shop, end to end, in long rolls that reach from eaves to ridge. The sloping seams are formed by turning up the adjacent edges of these rolls at right-angles; and those two "upstands" are interlocked by forming a seam at the upper edge and they are held to the roof by cleats. The standing seams are not soldered but are simply locked together with the cleats folded in at intervals of about one foot. Nails should be driven into the cleats only. The outer edges of the tin roofing should be turned over the upper edge of the wooden cornice and nailed about every 2 or 3 inches; or, if it connects with a metal gutter, the two should be locked and soldered together. Whenever a tin roof abuts against a wall or chimney the tin should be turned up a sufficient distance, at least 4 inches, to prevent water from rising over it; and against a brick wall it should be counterflashed with sheet lead, as described in Art. 205. When against wooden walls the roofing should be turned up against the boarding and the siding or shingles laid over it. The tin should be turned up, also, against all balcony-posts (see Art. 197) and the edges at the angles should be well soldered.

All tin roofs should be painted within a few days after they are laid, either with red lead, red oxide, Venetian red, or metallic brown, in linseed-oil.

A tin or copper roof should never be used as a floor unless it is

covered with a movable floor made of slats, as described in Art. 197.

208. COPPER ROOFS. Copper roofs are laid in the same way as tin roofs and the remarks in the preceding article apply as well to copper as to tin, except that it is not customary to paint copper roofing.

209. ASBESTOS SHINGLES. Asbestos shingles, made of asbestos and cement, have been largely used in recent years in place of wood shingles, slate, tile and other roofing-materials and wall-coverings. They are practically indestructible by the elements, are tough and elastic and can be laid on any ordinary, roughly sheathed roof. The asbestos "Century" shingles have been extensively sold in Europe under the name of "Eternit Slates." They may be exposed to the action of sea-air or sea-water without undergoing deterioration or change. They are also fire-resisting to a marked degree. They may be painted if desired, but this is not necessary for their preservation. They are made in a uniform thickness of ⅛ of an inch and of varying sizes and shapes, common sizes being 4 by 8, 8 by 8, 6 by 12, 12 by 12, 8 by 16 and 16 by 16 inches.

210. SLATE, TILE, GRAVEL, COMPOSITION, ETC., ROOFS. It is not the purpose to include in this volume of building-construction and superintendence all the various materials used for roofing. Shingles and tin have been briefly discussed, as on frame buildings they are used more frequently than other materials. For notes on slate, tile, composition, etc., for roofing, see "Architects' and Builders' Pocket-Book," F. E. Kidder.

211. SUPERINTENDENCE OF OUTSIDE FINISH AND ROOFING. 1. *Materials, Joints, Nailing, etc.* The superintendence of the various details of construction in wood described in this chapter is ordinarily quite a simple matter, although the work should be carefully inspected every two or three days to see that the material is of the quality specified and that the work is being executed in accordance with the full-size details. The superintendent should see that lookouts or furring-blocks, where required, are not spaced too far apart, that they are well nailed and that the finish is properly secured. He should see that the various members are put together in such a way that the joints will not be exposed to the weather; and wherever a particularly tight joint is required, that the parts are painted with white lead, slightly thinned with linseed-oil. For all work exposed to the weather it is better to use white lead and screws than to use glue. It is important to see that the shingles or clapboards are thoroughly nailed. It is not uncommon for shingles to be blown from the roof for lack of proper nailing. It is advisable to measure the "exposure" of the shingles to see that it corresponds with the specifications.

2. *Gutters, Conductors, Sheathing-Paper, etc.* When the gutters are to be lined with tin, the superintendent should not forget to see that the "fall" of the bottom of the gutter is sufficient and in the right direction. If the position of the conductors is not indicated on the drawings he should locate them before the gutters are formed. He should be sure that the kind of sheathing-paper specified is put on the walls and roof and properly lapped and that tight joints are made around all windows.

3. *Quality of Metalwork, Painting, etc.* Of the outside work, the metalwork and flashing require the closest inspection. Many builders and metalworkers are so used to doing a certain grade of work that when anything better is specified they are apt to overlook it, if given an opportunity, and to go ahead in the usual way. As a general thing the cheapest tin, the lightest galvanized iron and the smallest quantities that will possibly answer, are used where some contractors have their own way. The specifications, therefore, should always provide for a particular brand of tin, one that is stamped on every sheet and for a certain thickness, or gauge-number, of galvanized iron; and it is the duty of the superintendent to see that these are supplied. He should be careful to see that the tin or iron is painted on the under side before it is put in place, that the metal is of the width specified or shown on the drawings, particularly in the valleys, and that all joints are well soldered.

4. *Flashing and Counterflashing.* The flashing requires the closest scrutiny, for if this is improperly done there will be great danger of leaks. A leaky roof tends to injure an architect's reputation and to be a source of great annoyance. In some parts of the country the counterflashing around a chimney, or where a roof joins a brick or stone wall, is often omitted; or, if used at all, is made with tin and in a very slovenly way. It is always safest and best to specify lead counterflashings, "built in," as then there is little chance for a poor job. The flashings behind the chimney are also often left perfectly level, causing the tin to rust and often to leak. A wide chimney should always have a "cricket" behind it and a narrow one should have the flashing pitched at least an inch to one side. Another common fault in flashing is that the tin shingles are cut too small and as a result can be turned up against the chimney or wall about 2 inches only. For this reason it is best to specify the size of the tin shingles that are to be used. (See footnote with Art. 205.)

When counterflashing is put in after the walls are built, the superintendent should see that it is firmly wedged into the joints and that the latter are pointed with cement. The flashing against gable-walls that extend above the roof (see Art. 205) should be

given particular attention, as these places are even more apt to leak than those around the chimneys. If the architect wishes to be sure that he will have no trouble with leaks, he must not pass the flashing by with a glance, but examine it carefully in all its parts, as a single defect may cause a great amount of trouble.

5. *Leaks in Roofs.* On large roofs, or roofs that are much broken up, the superintendent should caution the workmen about leaving shingle-nails in the gutters and valleys, as they are frequently the source of leaks. The workmen are apt to step on them and push them through the tin or copper. This danger appears to be greater on large than on small roofs.

6. *Tin Roofs.* With a tin roof the matters that need watching are, the quality of tin, the fastening to the roof and the rejection of acid as a flux in soldering. Many of these points seem trivial and the inexperienced architect is apt to think that the builder will look after them for his own reputation, while he, the architect, is more interested in the ornamental part of the work and in seeing "how it is coming out." While there are builders who do care for their own reputation, there are also a great many who appear to think that anything that will pass is "good enough," and who, if they do not willfully slight the work, are very careless, to say the least. As the owner looks to the architect to see that the work is well done, the latter will find it is to his own interest to inspect every portion of the work very carefully to see that everything is carried out as specified, even if the builder does say that he is "too particular," and that "it is all nonsense."

CHAPTER V.

Interior Woodwork.

1. ROUGH WORK.

212. TIME OF PUTTING IN THE ROUGH WORK. The underfloors are generally laid as soon as the joists are in place and bridged, and all bearing partitions, or at least enough of them to support the floor-timbers, are set at the same time; but all other rough interior woodwork is usually left until the building is enclosed and protected from the weather.

213. UNDERFLOORS OR SUBFLOORS. In some parts of the country it is customary to lay a rough underfloor in every building that has wooden floors; in other parts underfloors are seldom laid except in the very best buildings. However, the saving in cost effected by omitting them is usually very slight, while there are several advantages in their use. In the first place, an underfloor, especially if laid diagonally, greatly stiffens the building during its construction, and it is not only a great convenience to the workmen but also allows the laying of the overfloor or finished floor to be postponed until the building is nearly finished. Moreover, without an underfloor it is impossible to introduce any efficient deadening-materials unless boards are cut in between the joists. For these reasons it is advisable to specify underflooring whenever the limit of cost will permit, even if some ornamentation has to be omitted.

Before laying the subfloor, the joists should be leveled, as the surface on which hard-wood flooring is to be laid must be level and smooth. If the floor is not level, the nails will work loose in the low spots and the surface will become uneven. This will cause the hard-wood floor to "give" when walked upon and make it creak. The creaking is invariably blamed, although unjustly, upon loose matching.

These suggestions should be borne in mind, also, when laying hard-wood floors over old, pine floors, as the surface must be level in order to get good results.

The cheapest kind of lumber may be used for underflooring.

Spruce is sometimes used, but hemlock is the wood generally employed in the eastern and northern states and, so long as it is sound, native pine in the western states. The boards should be dressed on one side to a uniform thickness and the narrower they are the better. The usual thickness is ⅞ of an inch and the width runs up to 6 inches. The manufacturers of hard-wood flooring advocate from 4 to 6-inch tongued-and-grooved pine. In the better class of buildings the boards should be laid diagonally across the joists. Pieces of scantling are often cut in between the joists at the walls to support the ends of the floor-boards in case the latter are laid close to brick walls or to the outside boarding of stud-walls; and these floor-boards are sometimes cut around the studs. But, aside from the difficulty of concealing any cracks or openings between the flooring and the base-board when the floor-boards do not run

Fig. 328. Tile Floors in New Buildings.

back under the base, it is better to leave a space all around the room and outside of the subfloor to allow for some swelling. This space will be concealed from view by the base and the quarter-round when the floor is finished. It costs a little more to lay underflooring diagonally on account of the waste at the ends; but it greatly stiffens the building and gives a much smoother surface to the overfloor, especially if it is matched. The boards should be nailed securely over every bearing with two eightpenny nails, but should not be driven so tightly together that they cannot swell without bulging. When laid they should be swept clean and allowed to dry thoroughly. It is advisable to lay a good water-proof paper on the subfloor or if it is necessary to deaden the sound, especially in the upper stories, a good deadening-felt should be used. If furring-strips are used on the subfloor, they should be nailed securely to the joists, and leveled. (For data relating to "Overfloors or Finished Floors," see Art. 319 and following Articles.)

214. PREPARATIONS FOR TILE FLOORS. 1. *Foundations for Tile Floors.* A good foundation is always necessary;

it should be solid, perfectly level, and free from spring or vibration. Tiles must always be laid upon a concrete foundation, prepared from the best quality Portland cement and clean, sharp, washed sand and gravel.

2. *Tile Floors in New Buildings.* When tiles are laid on joists in new buildings, the joists, if possible, should be set 5 inches below

Fig. 329. Tile Floors in Old Buildings.

the intended "finished" floor-line; and they should be spaced 12 inches on centers, thoroughly bridged to make a stiff floor and covered with 1-inch rough boards, not over 6 inches wide, 3 inches being preferable. These boards should be laid about ⅛ of an inch apart at the joints to allow for swelling and should be thoroughly nailed. (See Fig. 328.) A layer of roofing-paper on top of the rough floor will protect the boards from the moisture of the con-

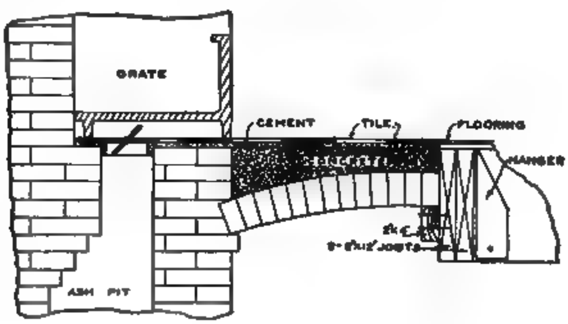


Fig. 330. Tile Hearth on Brick Arch.

crete, and prevent moisture from dripping through to the ceiling below.

3. *Tile Floors in Old Buildings.* Cleats are nailed to the joists 5 inches below the intended "finished" floor-line, and short pieces of boards, not over 6 inches wide, ⅛ of an inch apart, fitted in between the joists upon the cleats and well nailed. The joists must be thoroughly bridged. Roofing-paper should be laid as above directed.

The corners on the upper edges of the joists should be chamfered off, so as to leave a sharp point (see Fig. 329), as otherwise the flat surface of the joists will make an uneven foundation. When the strength of the joists will permit, an inch or more should be cut off the top. Where joists are too weak, they should be strengthened by 6-inch-wide cleats running the full length of the joists and thoroughly nailed to them. When a solid subfoundation is thus prepared, concrete is placed upon it as above directed.

4. *Foundations for Tile Hearths.* These should be placed upon brick arches if possible, to insure a perfect fire-protection, and they should be then covered with concrete in the same manner as tile floors. (See Fig. 330.) If placed upon a subfoundation of wood, the concrete should be at least 6 inches thick. (See Fig. 331.)

Fig. 331. Tile Hearth on Concrete and Wooden Subfloor.

5. *Foundations for Tile Walls.* A good foundation is absolutely necessary, and in order to prevent the tile from coming loose, the foundation should be solid, perfectly plumb and free from any spring or vibration before the scratch-coat is applied.

6. *Tiles Placed on Studding.* When tiles are placed on studding, the studs should be spaced 15 inches on centers, thoroughly braced with 2 by 3 or 2 by 4-inch scantlings, nailed horizontally between the studs and spaced about 12 inches on centers, to prevent vibration. The studding should be covered with expanded-metal lath. (See Fig. 332.)

7. *Tiles Never Placed on Wood or Plaster.* Tiles must never be placed on wooden lath or on plaster. If placed on "plaster-blocks" or "plaster-boards" the blocks should be driven full of nails or be covered with wire lath. Plaster-block material does not form a good bond with cement and in a short time the tiles tend to come loose and drop off.

215. DEADENING FLOORS. In nearly all inhabited buildings it is desirable to prevent the conduction of sound through the floors or walls, from one room to another; and in school-houses, office-buildings and apartment-houses sound-proof construction should be considered necessary. The usual method of attempting to prevent the passage of sound through the floors is by lining the

Fig. 332. Tiles Placed on Studding.

floors with some material that is expected to absorb and dissipate sound-waves. As commonly practiced, however, this method is usually only partially successful, owing partly to the failure of the lining to fully accomplish its object, but to a greater extent to the solid connection maintained between the floor and ceiling by means of the nails and joists. The author is of the opinion that perfect resistance to sound-waves can be obtained only when the flooring and the ceiling beneath have no direct connection by rigid bodies, either by contact or by nailing.

The most effective sound-proof construction is undoubtedly that described in Art. 105, where two sets of joists are used. Owing, however, to the great danger of such construction in case of fire, it is not to be recommended, except in rare instances, and then only

when the ceiling is fire-proofed and all communication with vertical air-spaces cut off.

The next most effective wooden construction, in the opinion of the author, is that in which the overflooring and underflooring are separated by an efficient deadening-material, and not connected by any nails. Such a construction is shown in Fig. 333. Here the cleats on which the overflooring is laid are merely set on top of the deadening and not nailed. This could be further improved by filling the space between the cleats with mineral wool and by

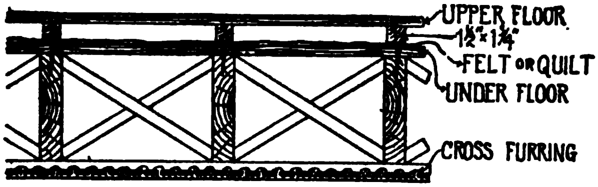


Fig. 333. System of Deadening Where Over and Underfloors are Used.

placing a layer of mineral wool 1 or 2 inches thick on top of the lathing.

As already stated, however, the common custom is merely to lay a thickness of deadening-material between the overflooring and underflooring, and nail the overflooring through it and the underflooring into the joists. While this method is not perfect, if a good deadener is used it partially accomplishes its object. (See, also, Arts. 192, 213 and 216 to 219.)

216. DEADENING-MATERIALS IN GENERAL. At this point it is deemed best to describe the more common materials used for deadening, that is, for absorbing and dissipating sound-waves. Most of these materials are of the nature of paper felts; some, however, resemble carpet-lining. All of them are put up in rolls or bales, usually 3 feet wide and containing 500 square feet. (See, also, Arts. 192, 213, 215 and 217 to 220.)

217. SHEATHING-QUILT.* This consists of a felted matting of eel-grass held in place between two layers of strong Manila paper by quilting. Its appearance is shown in Fig. 334. "The long, flat fibers of eel-grass cross each other at every angle and form within each layer of quilt innumerable minute dead-air spaces, that make a soft, elastic cushion. This

Fig. 334. Sheathing-Quilt.

* Made by Samuel Cabot (Inc.), Boston, Mass.

gives the most perfect conditions for non-conduction." Eel-grass is chosen for the filling because of its long, flat fibers, which especially adapt it for felting; because of its great durability,* and its resistance to fire; and because, owing to the large percentage of iodine which it contains, it is repellent to rats and vermin. This quilt is made in single and double-ply thickness, and is put up in bales of 500 square feet. It costs, in Boston, $5.25 and $6.25 per bale, respectively. It is also now made with a covering of asbestos, which renders it thoroughly fire-proof. To obtain the best results in floor-deadening, the double-ply should be used in the manner shown in Fig. 333, the floor "floating," as it were, upon the quilt. The material is also very efficient for heat-insulation. When used for this purpose there is no objection to nails passing through it.

Another material used for similar purposes is the Keystone Hair Insulator.† This consists of thoroughly cleansed cattles' hair, between two layers of strong, non-porous building-paper, securely stitched together. The hair is chemically treated, so that it is coated with lime, which makes the finished material vermin-proof and odorless. (See, also, Arts. 140 and 192.)

218. FELT PAPERS. There are a great many felt papers for lining floors and a few are made fire-proof by means of chemicals. As a rule these felts are cheaper than Cabot's "Quilt," although the saving in an ordinary residence would be but little, and even among the felts themselves there is quite a difference in cost. In choosing a felt paper for lining, the architect should select one that is soft and elastic enough to form a cushion, and the thicker the felt, provided it has the above qualities, the greater will be its non-conduction. Some felts are made water-proof by an asphalt center, which is an advantage in case of fire or leaks, but some authorities think that it is doubtful if such felts obstruct the passage of sound as well as felts without the asphalt center. The experience of some acoustical experts seems to show that one of the best methods of deadening is by a combination of heavy hair felt or felt paper with sheets of galvanized iron. Two layers of felt, each from ½ to 1 inch thick, are placed on either side of a single layer of galvanized iron, the latter resting freely between the felt layers. This form of construction is to be preferred where the deadening-material is not attached to the enclosing woodwork. An additional layer of iron and of felt increases the effectiveness of the combination. (See, also. Arts. 140, 192, 216, 217 and 219.)

219. SOUND-DEADENING FELTS. These deadening-felts

* A sample of eel-grass 250 years old and in a perfect state of preservation, may be seen at Mr. Cabot's office.

† Made by H. W. Johns-Manville Co., New York.

are made by various manufacturers. In one of these felts * the material itself is rather hard and thin, but it is pressed in such a way as to form small indentations or air-cells, as shown in Fig. 335. This makes it elastic and breaks up the sound-waves. The cost of this material in Boston is about $3.50 per 500 square feet. (See, also, Arts. 140, 192, 216, 217 and 218.)

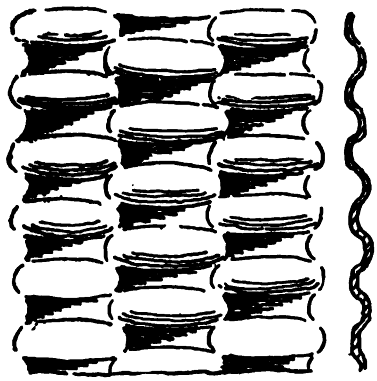


Fig. 335. Florian Sound-Deadening Felt.

220. ASBESTOS SHEATHING. Sheathing-papers or building-felts, made of asbestos, are used to a considerable extent for floor-linings and for covering the outside walls of wooden buildings, principally on account of their fire-proof and vermin-proof qualities. These papers are well known in the trade and can be procured without difficulty. They are supplied by the manufacturers in 50 or 100-pound rolls, 36 inches wide, on a basis of the following scale of weights:

4	pounds	to	the	100	square	feet.	18	pounds	to	the	100	square	feet.
6	"	"	"	100	"	"	20	"	"	"	100	"	"
8	"	"	"	100	"	"	24	"	"	"	100	"	"
10	"	"	"	100	"	"	32	"	"	"	100	"	"
12	"	"	"	100	"	"	1/16	of	an	inch	thick.		
14	"	"	"	100	"	"	3/32	"	"	"	"		
16	"	"	"	100	"	"	1/8	"	"	"	"		

The last three thicknesses are used only for special purposes where an unusually thick lining is desired for possible fire-protection around exposed flues, for chimney-breasts, etc. When the weight of paper exceeds 32 pounds to the square foot it is known as "roll-board" and is no longer classed by weight per 100 square feet, but by thickness.

For floor-linings, 16-pound paper is generally employed, this weight being sufficiently thick and strong to resist ordinary damage in application and in handling. Asbestos felts and building-papers appear to have approximately the same effect in retarding the passage of sound-waves as other felt papers of a relatively similar thickness and quality, while their fire-proof and vermin-proof quali-

* Neponset Florian Sound-Deadening Felt, made by W. W. Bird & Son, East Walpole, Mass.

ties are a distinct advantage. The cost of asbestos paper and building-felts, while somewhat greater than that of the ordinary papers used for similar purposes, is not excessive. The market price varies from 2 to 2½ cents per pound, depending on the fluctuations of the market. For example, the cost of 100 square feet of 16-pound asbestos paper varies from 32 to 40 cents, according to the market.

221. MINERAL WOOL. There are at least two kinds of mineral wool made in this country. The more common quality is made by mixing certain kinds of stone with the molten slag from blast-furnaces and converting the whole mass into a fibrous state. The best slag for the purpose is that which is free from iron. The appearance of the finished product is much like that of wool, being soft and fibrous, but in no other respect are the materials alike. Mineral wool made from slag appears in a variety of colors, principally white, but often yellow or gray, and occasionally quite dark. The color, however, is said to be no indication of the quality, as all of the peculiar properties of the material are present in equal proportions in any of the shades. The other kind of mineral wool is known as "rock-wool," and is made from granite rock raised to 3,000° Fahr. It is claimed that as it is absolutely free from sulphur, it is the only odorless wool manufactured, and it has been approved by the United States War Department. It has the same general appearance as that made from slag, and is white in color.

Both of these materials consist of a mass of very fine, pliant, but inelastic, vitreous fibers interlacing in every direction and forming an innumerable number of minute air-cells. Its great value in the insulation and protection of buildings lies in the number of air-cells which it contains, its consequent non-conduction of heat, and its fire-resisting qualities. In wool made from common slag 92 per cent of the volume consists of air held in minute cells, while in the best grade the proportion of air reaches as high as 96 per cent. This confined air makes it one of the best, if not the best, of the non-conductors of heat. Aside from these qualities it is very durable and contains nothing that can decay or become musty. Being itself incombustible it greatly retards the burning of wooden floors or partitions if their inner spaces are filled with it.

The greatest value of this material is as an insulator of heat, but it is also a valuable non-conductor of sound. In the opinion of the author, however, it can be considered only as a "muffler" of the sound-waves, for he can think of no practical way in which it can be used so as to separate entirely the floor and ceiling. It would be crushed by laying floor-cleats upon it. As a muffler or filling between the beams, however, there is probably nothing that is

superior. In the end, then, it would seem that the most complete insulation from sound, without separate beams, would be obtained by "floating" the flooring on Cabot's Quilt or a very thick felt, with the spaces between the floor-cleats filled with mineral wool.

Mineral wool, when used alone as floor-deadening, may be laid on boards cut in between the joists, or on top of sheathing-lath when that material is used. The wool should be at least 2 inches thick. Again, mineral wool is particularly desirable for filling the spaces between the studs of outside walls and partitions and between the rafters of the roof. It may be used to great advantage, also, in partitions around bath-rooms or water-closets, and around water-pipes when placed in partitions. In outside walls and attic roofs, as a protection from the heat of summer or the cold of winter, it is of the greatest value. By lathing the under side of the rafters with sheathing-lath, and spreading on top a layer of 2 or 3 inches of mineral or rock-wool, the comfort of the room below will be greatly increased. Flat roofs over inhabited rooms may be covered with rough boards and 1¾-inch cleats nailed on top, as in Fig. 333, the spaces filled with wool, and the roof-sheathing then nailed to the cleats. This would not only greatly increase the comfort of the rooms, but greatly retard the progress of fire from the outside. When insulating against heat, nails driven through the insulating material do no harm. When using mineral wool in floors it should be packed in very closely, but not jammed so as to break the fibers, which are naturally very brittle. In partitions it is packed between the lathing, so as to fill the space completely, the wool being put in after the lathing has reached a height of 2 or 3 feet, then more laths put on, the space filled, and so on to the top; it should not be dropped from any considerable height, for the breaking up of the fibers destroys the insulating qualities of the material. In fact the tendency of mineral wool to settle and consolidate, if improperly or too loosely packed, is the only drawback, except cost, to its use for insulation. The wool behind the lathing will not prevent the plaster from keying.

Mineral wool is sold by the pound, and in estimating the quantity of wool required, 1 pound per square foot of filling, 1 inch thick, should be allowed for ordinary wool and ¾ of a pound for selected wool. The price of the ordinary wool is about $1.25 per hundred pounds, and of selected wool $2. (See, also, Art. 117, Chapter II, and Art. 222.)

222. FIRE-STOPS AND MICE-STOPS. In every good residence provision should be made to prevent mice from passing through the spaces between the studs and between the floor-joists. Much may be done with a very little additional expense to prevent

the rapid destruction of the building in case of fire. Any material that will stop the progress of fire will also stop the passage of mice, but provisions may be made for stopping mice that are not sufficient to stop fire.

When mice-stops alone are to be provided, tin will be found to be the most convenient material. It should be so used that it will be absolutely impossible for mice to ascend from the cellar into the outside walls or into the partitions, and the second-story walls and partitions should be protected in the same way. If the building has an underfloor the boards should be extended close against the outside sheathing of a wooden building, and against the walls of a brick or stone building, and carefully cut around all studs. If there is no underfloor the finished flooring, if laid before plastering, should be extended in the same way. The space between the outside studs and between the sheathing and plaster should then be covered with tin, turned up 1 inch against the studs and sheathing and tacked. Every space, no matter how small, must be protected in this way or else solidly filled with brick and mortar.

If the partitions are set on top of the flooring, a strip of tin 2 inches wider than the sole-piece should be laid under it, as shown in Fig. 107.

If the studding rests on top of a partition-cap below, a strip of tin may be laid between the studs on top of the underfloor and turned up 1 inch against them. A better precaution, however, is to fill the spaces between the studs on top of the partition-cap with five or six courses of salmon bricks and mortar, as shown in Figs. 104 and 106, as this also forms an efficient fire-stop. Where the chimneys are furred, or studded around, the space from the chimney to the back of the lathing should be closed with tin or brickwork. On brick walls that are furred by strapping, the easiest way to form a stop is to plaster between the strapping and flush with it for a distance of 10 or 12 inches just above and below the floor-joists.

In localities where salmon bricks can be bought for $4 or $5 a thousand it will be about as cheap to fill the spaces between the studs with bricks and mortar as with tin. If asbestos sheathing is used as a lining between the floorings it may be fitted around the studs in place of the tin; and it should be turned up against the sheathing and studs and tacked. When the owner is willing to go to the expense, it will be much better to fill the entire height of the spaces between the studs, both in walls and partitions, with mineral wool, and thus gain the advantages of sound-insulation, heat-insulation and slow combustion, as well as a means to stop mice.

If the architect undertakes to provide mice-stops at all he should see that the work is done thoroughly, for as mice can go through a

very small hole, if a few holes are left the work done will be almost useless.

Fire-stops have been described in Art. 117, Chapter II, but the work is generally done after the building is roofed in and while the carpenter is getting ready for the lathers. If the walls and partitions are fire-stopped it is best to complete the work by laying a fire-proof or incombustible lining between the floorings, as described in Art. 215.

The work described in the last four articles will not add to the appearance of the building, and to see that it is thoroughly done requires close inspection. When faithfully carried out it greatly enhances the value of the building as a place to live in, adds to its security, and may possibly save a great loss from fire. It is in many points such as these, not apparent from a casual inspection, that architects' houses usually are, and always should be, superior to those of the speculative builder. (See, also, Fig. 118 and Art. 221.)

223. BACK-PLASTERING. This term is commonly used to designate plastering that is applied between the studs or the rafters to make the building warmer and to keep out the wind. Before the introduction of the present high grades of sheathing-papers, back-plastering was quite common in the better class of dwellings in the northern states. It is now used to a much less extent, as the same object can be more cheaply, and the author believes more efficiently, attained by the use of high-grade sheathing-paper, felt, or quilt. On the sloping roofs of attic rooms, however, back-plastering may be used with much advantage in conjunction with the sheathing-paper; and even on the walls it will add much to the comfort of a frame dwelling, if properly applied.

Where ordinary sheathing is used to cover the frame and rafters, back-plastering should be applied by nailing two vertical rows of laths to the inside of the sheathing in each space between the studs or rafters, then lathing horizontally on these strips and plastering one heavy coat of haired mortar in the usual manner. In lathing between rafters 20 inches on centers, three rows of vertical laths should be used. The plastering should be applied so as to come well up to the rafters or studs, and leave no unprotected spaces.

224. FURRING IN GENERAL. This term is commonly used to designate work that is built out from the constructive members to receive lathing or metalwork and sometimes sheathing or finished woodwork. It is also sometimes called "false work," as the surfaces which it forms are hollow and do not indicate the actual construction.

In fire-proof buildings all furring should be done in tile or metal,

as described in Arts. 484, 485 and 486, "Building Construction and Superintendence, Part I, Mason's Work," by F. E. Kidder; but in all other buildings the cheaper grades of wood in small pieces are used for the furring, as they generally have to support nothing heavier than lath and plaster.

There is usually but little furring on the outside of buildings, the blocking for the cornice or belts and the furring for metalwork or for curved roofs being about all that is generally required. On the inside, however, considerable furring is often required for the lathing in the way of strapping the walls and ceilings, furring out brick and stone walls, and in forming false beams, arches, coves, cornices, etc. This inside furring is usually done immediately after the roofing is on and while the outside of the building, if of wood, is being finished.

For furring-stock cheap grades of pine, spruce or hemlock are used in the northern and western states. Pine is preferable because it warps and twists less than the others. The stock may be rough, but where it is used for cross-furring, etc., it is better to have it dressed to an even thickness. This adds but little to the cost. (See, also, Arts. 225 to 229.)

225. CROSS-FURRING OF CEILINGS. In many parts of the country it is the common custom to "cross-fur" the ceilings or under side of the floor-joists or rafters with 2 or 2½ by ⅞-inch strips, as shown in Figs. 104 and 106; but this custom is not universal. (See Arts. 88 and 122, Chap. II.) If the floor-beams were all dressed to a pattern there would not be much advantage in cross-furring. As it is, the principal advantage of cross-furring is that it is more practicable to get a level ceiling by it, and the floor-joists may be spaced from 14 to 18 inches apart, while the bearings for the laths may be spaced either 12 or 16 inches, as desired, without much additional cost. Even if the bottom of the joists are all on a level when set, some will bend more than others; and, as the furring is put on some time after the joists are set, this unequal deflection may be in part overcome. On the other hand, cross-furring leaves a space between the bottom of the floor-joists and the laths sufficient for the passage of vermin and of fire.

When the ceiling is to be cross-furred no particular care is taken to have the floor-joists level on the bottom, as any inequality may easily be overcome when putting on the furring-strips. This is done by cutting the bottom of the joists that are lower than the average and blocking up those that are higher, as shown in Fig. 336. In putting up the furring a strip is first put up at one side or at the center of the ceiling and carefully leveled from end to end; the other strips are then all leveled from that by means of a long straight-

edge and a carpenter's level. The usual size of the strips is 1 by 2 inches; if the joists or rafters are more than 18 inches apart the strips should be 1⅛ by 2 inches. In all first-class buildings the strips should be spaced 12 inches on centers, although 16 inches is the more common spacing because it is a little cheaper. The strips should be well nailed at every bearing with tenpenny nails, cut nails holding best. Where the under side of the roof forms the attic-ceiling the rafters are often cross-furred in the same way as the floor-joists. (See, also, Arts. 224 and 226.)

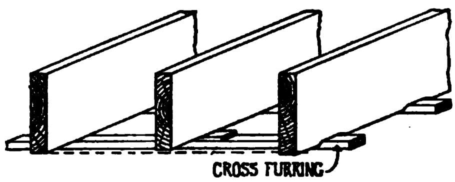


Fig. 336. Cross-Furring of Ceilings.

226. SUSPENDED CEILINGS UNDER FLAT ROOFS. In the eastern states the ceiling-joists under a flat roof are seldom built into or supported by the walls, but are hung from the roof-joists in the manner shown in Fig. 337, and carefully leveled as they

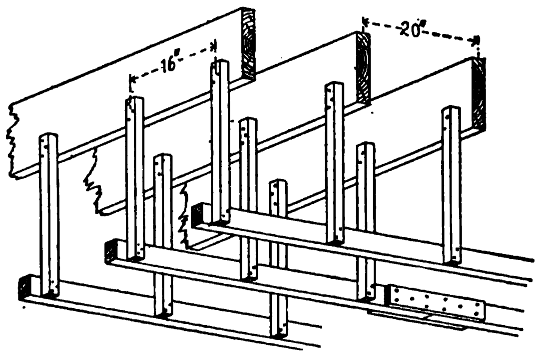


Fig. 337. Suspended Ceilings Under Flat Roof. Eastern Method.

are put up. It should be noticed that in this figure the ceiling-joists run at right-angles to the roof-joists, and if the spacing of the former is different from that of the latter they must do so. If the spacing of the two sets of joists is the same the ceiling-joists may be hung directly beneath the roof-joists, using 1 by 3-inch boards for the suspending-pieces. The construction of this work is generally specified under the head of "furring."

When the walls are of brick and the bricks are laid from an outside scaffolding, this method of supporting the ceiling is possibly

the most economical; but when the walls are laid from the inside, as is the custom in the western states, the author believes that it is better to build the ceiling-joists into the wall and tie them in the same way as the floor-joists. Where the span is not greater than 13 feet, 2 by 6-inch joists will be stiff enough, but for greater spans it will be more economical to use 2 by 4 or 2 by 6-inch joists and truss them from the roof-joists, as in Fig. 338. By trussing each pair of joists the roof may be made very stiff with less timber than is required by the method shown in Fig. 337, and there is less

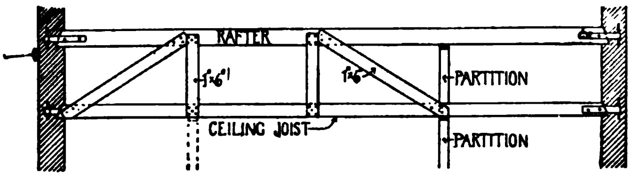


Fig. 338. Suspended Ceiling, Trussed. Western Method.

"kindling-wood" in the roof-space.* If the ceiling-joists are anchored to the walls, as they should be, they also greatly strengthen the building. Where the ceiling-joists are built into the walls their inner ends are supported by the interior partitions and another set of studs placed on top of the caps to support the roof-joists or rafters.

The ceiling-joists are also utilized by the brick-masons for a scaffold, a temporary partition being set under them about 5 feet from the wall, as shown by the dotted lines, and allowed to remain until the joists are permanently braced. In frame buildings the outer ends of the ceiling-joists may be supported by false girts. When the rooms under a flat roof are inhabited a space between the ceiling and the roof adds greatly to the comfort of the rooms, and it is desirable that the average height of this space should be at least 2 feet. This space also affords opportunity for running pipes and wires above the ceiling-joists. Of course, the greater the height of the air-space the greater becomes the expense of suspending the ceiling. In Colorado suspended ceilings are seldom, if ever, found.

The ceiling-joists, whether suspended or built-in, are usually cross-furred if the other ceilings are, although this is not really necessary with the suspended ceiling. (See, also, Arts. 224 and 225.)

227. FURRING OF WALLS. Except in the dry climate of the Rocky-Mountain region it is customary to fur all outside brick walls, that are not built hollow, with 1 by 2-inch strips, nailed to

* This trussing or bracing should be specified in connection with the roof-framing.

the walls vertically and set 12 or 16 inches on centers. In spite of the fact that these strips can generally be made secure by driving the nails into the joints of the brickwork, using two nails close together if necessary, very often thin strips of wood are built into the inside of the wall at intervals of 2 feet in order to form "nailings" for the furring. If such strips are used, they should not be more than ⅜ of an inch thick. Their use, however, is not desirable and should not be permitted in buildings over two stories in height. (See Art. 361, Kidder's "Building Construction and Superintendence, Part I., Masons' Work.") When stone walls are to be furred or "strapped" they are often "plugged" to form "nailings." This "plugging" is done by raking out the mortar and driving in wooden plugs about ⅞ of an inch in diameter and 4 or 5 inches long. The plugs should not be more than 2 feet apart in the length of the furring-strips. To plug a wall takes considerable time, and unless the walls are quite high it is usually about as cheap to set 2 by 4-inch studding inside of the wall, and secure it to the floors at top and bottom, although this of course takes up a little more space than the "strapping."

Whichever method is used the furring should be put up plumb and true, so that the walls when lathed and plastered will form a true plane. As plaster can be applied to brickwork as well as to lathing, it is best not to fur inside brick walls, as the space so left may become a passage for vermin or fire. Plaster does not adhere well to some kinds of smooth stone and on that account inside stone walls are sometimes furred before being plastered.

Where there are to be inside shutters it is often necessary to "fur out" or thicken the wall to form "pockets" for them. If this increase in thickness is 2 or more inches, the furring should be done by independent studding and should be particularly described in the specifications. All studding for furring should be bridged to stiffen it and to keep it in place, as described in Art. 113. (See, also, Arts. 224, 228 and 229.)

228. FURRING AROUND CHIMNEYS. In the eastern states it is customary to fur around all chimneys with 2 by 3 or 2 by 4-inch studding, usually set flatwise, except in outside walls, as shown in Fig. 339. The object of this is to form a nailing for the base, chair-rail or picture-molding, and also to prevent the cracks that are almost sure to occur where a wooden wall joins a

Fig. 339. Furring Around Chimney. Eastern Method.

brick one. The studding should be kept at least 1 inch from the brickwork, should be set plumb, and bridged at least once; the angles should be made square. If the chimney is in a brick wall it is usually furred around in the same way.

Fig. 340 shows the way in which a chimney should be built which it is desired to have project on the outside of a frame wall. A 4-inch lug is carried up on each side of the chimney, as at *L*, and the boarding and wall-covering are extended over it. While this construction can easily be made tight, it very much weakens the wall by cutting the girts and plates; it should be used with caution and not near an angle of the building.

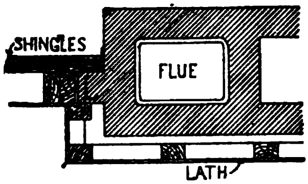


Fig. 340. Furring Around Chimney Projecting Through Frame Wall.

When there is a fireplace the furring is set so that it forms a breast wide enough to receive the mantel. An opening is left large enough to receive the facing around the fireplace-opening and the facing is usually set flush with the plaster (see Fig. 235, Kidder's "Building Construction and Superintendence, Part I, Masons' Work"). When there is a thimble for a stove-pipe, a square recess at least 10 inches larger than the diameter of the pipe, should be framed in the studding opposite the opening. The thimble is generally set so as to project ½ an inch from the brickwork, plastering is applied directly to the chimney at the back of the recess, and the sides are cased with wood, as shown in Fig. 341. As such a recess does not have a good appearance, a better method is to cover it with expanded or sheet-metal lath, leaving a round hole through which to pass the thimble. A thimble 8 inches long can then be used and the breast plastered without a recess. The sides of the studding back of the plastering should also be covered with tin, so that there will be no danger from fire.

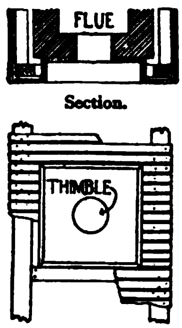


Fig. 341. Framing Around Pipe-Opening in Chimney.

In some of the western states furring around the chimneys is almost invariably omitted; and the author, after several years' experience with both methods, is of the opinion that, except against outside frame walls, it is better to use fire-clay flue-lining and then plaster directly on the brickwork. Where the chimney is furred it is difficult to stop completely the space at the floor-levels, and if fire does occur it has a chance to make considerable headway

before it is discovered. With flue-lining, and the outside of the chimney plastered to the floor, there is no objection to nailing the base or other molding to the chimney, so that the only objection to this method is in the probability of cracks occurring in the angle with the woodwork. By building the chimney as shown in Fig. 342, and covering the flush side with metal lath, lapped onto the studding, the likelihood of cracks will be avoided.

If the chimney is to be wainscoted the wainscoting must be kept outside of the plaster. When the chimneys are to be plastered the breasts for fireplaces must be carried up in brick, but in many localities this is fully as cheap as furring and lathing, and certainly more fire-proof.

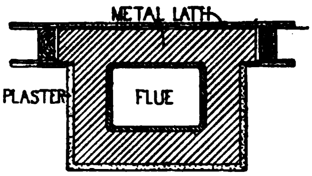


Fig. 342. Plastering Directly on Chimney.

When rooms are to be finished in the attic, the studding at the sides and the collar-beams or ceiling-joists (see Fig. 129) are usually specified under the head of "furring," and, unless they are required to support the roof, are put up after the roof is completed. (See, also, Arts. 224 and 227.)

229. FURRING FOR FALSE BEAMS, ARCHES, CORNICES, ETC. Besides the usual cross-furring there is generally more or less special furring required in forming false beams, arches, cornices, coved ceilings, rounded corners, etc., and in preparing solid beams and posts for plastering.

Wherever a solid beam, post or lintel is to be plastered on wooden lath, the timber should be furred with strips at least ¾ of an inch thick to afford a clinch for the plaster, and on vertical surfaces these strips should always be put on so that the laths will be horizontal, as in Figs. 89 and 96. Where it is impracticable to use furring-strips, metal lath or expanded metal, should be used. In no case should wooden laths be nailed against a solid timber. Rounded corners in partitions should have the studs set not over 10 or 12 inches apart, and they should be bridged every 3 feet with solid bridging cut to the curvature of the corner. When the radius is less than 3 feet the laths are usually put on diagonally and bent around the corner. They should never be put on vertically. When the angles formed by the walls and ceiling are to be coved, or when heavy plaster cornices are to be used, a furring of boards, cut to the shape of the cove or to the general shape of the cornice, must be used. These furring-blocks or boards should be at least a full inch, and, if very large, at least 1¼ inches in thickness. They should be set 12 inches on centers, as the close spacing makes a much better job of lathing and a firmer ground for receiving the

plaster. For plaster cornices the blocks should be cut so as to require as little stucco-work as possible (consult, also, "Building Construction and Superintendence, Part I, Masons' Work," by F. E. Kidder, Art. 664), and then lathed, as in Fig. 343. In forming false beams for plastering, a skeleton is generally built, as shown in Fig. 344. This skeleton is suspended from planks, *B*, *B*, which are spiked to the under side of the floor-joists or ceiling-joists above, or to blocks let in between them. If the beams are quite shallow solid blocks of plank, cut to the proper shape to receive the lathing, may be nailed to the under side of the joists or to the cross-furring. Where, however, the depth of the beam is 12 inches or more, the construction shown in Fig. 344 is much the best. If the beams are to be cased with wood, solid blocking is generally employed for furring, as shown in Fig. 504.

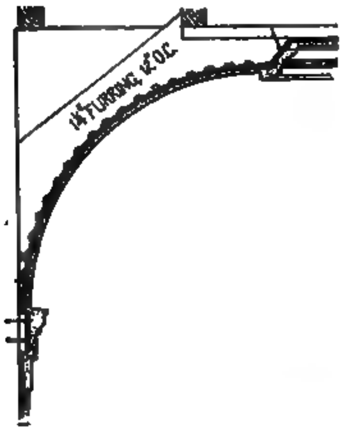


Fig. 343. Furring for Plaster Cornices.

False arches are usually formed in a similar manner, except that the vertical pieces, being longer, should be 1¾ inches thick, and a curved rib should be cut to form the edge of the soffit and to receive the laths, as in Fig. 345.

Fig. 344. Furring for False Plastered Beams.

The essential points in regard to all furring are that it be strongly secured and that it be put up perfectly straight and true. This is

of especial importance in connection with beams and cornices, as any irregularity can not well be overcome in the plastering, and the least deflection is readily discovered by the eye. Further it is desirable that the blocks or strips that receive the laths shall not be spaced more than 12 inches on centers. The exact shape of the furring for beams, coves, cornices, etc., should be shown by full-size details or large-scale drawings.

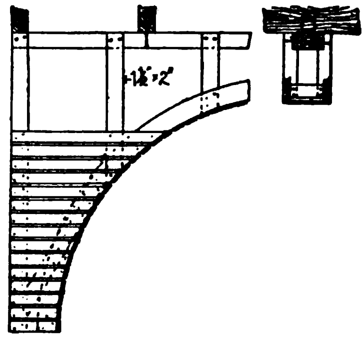


Fig. 345. False-Arch Construction.

230. GROUNDS. These are usually narrow strips nailed around openings in walls, furring or studding, to stop the plastering, and to form a guide for the workman. They are also placed behind base-boards, wainscoting, etc. The position of the ground around windows is shown in many of the window-frame details, Chapter III, by the piece marked *G*, and around door-frames by the same letter in Fig. 395; in Figs. 226 to 228 it is indicated by diagonal lines. Grounds should always be set so that their face will be flush with the plastering and ½ an inch back from the outer edge of the finish, so that the latter will lap that much over the plaster. They should be perfectly straight and plumb. As the plasterer is supposed to bring the plastering to the face of the grounds, if the latter are not straight or plumb the plastering will not be. It also is obvious that the thickness of the grounds regulates the thickness of the plaster. Where the plastering is applied to wooden laths the grounds should be ¾ of an inch thick for two-coat work, and ⅞ of an inch for three-coat work. Where it is applied directly to brickwork or tiling, or, with a few exceptions, to any of the metal laths, ⅝-inch grounds are generally used. The thickness of the grounds should be given in the specifications; the width varies from 1¼ to 1¾ inches.

For first-class work grounds should be put behind the base, chair-rail, wooden cornices and all inside finish to insure that the plastering will be straight. On brick walls grounds also afford a nailing for the wood finish. When the "window-trim" and "door-trim" or "casing" is made up of several parts it is often necessary to put on wide grounds to form a back for the finish. The ground behind the base should be laid so as to receive the upper edge of the base and the bottom of the base-moldings, as in Figs. 395 and 481. It is also desirable to have another ground at the bottom.

In a great many cheaply built buildings the grounds are entirely

omitted, except where necessary to form nailings for the wainscoting. The plastering is simply brought to the edge of the door and window-frames and carried to the floor, without much regard whether it is straight or not. As a result when the finish is put up the plastering makes a wavy line behind it, and the irregularity is frequently so great that the finish is "in winde." The only practical way in which the finish can be made to fit nicely against the plastering is by the use of grounds, and they should always be specified. The woods commonly used for them are spruce and the cheaper grades of white pine.

231. WOODEN CORNER-BEADS. There are two kinds of corner-beads used in buildings: *A*, those which are put up before plastering, and *B*, those which are nailed to a projecting angle outside of the plastering. The latter kind are included in the interior finish, and will be described under the name of "angle-beads." (See Art. 293.)

The corner-bead proper is really a ground for a projecting angle, as it forms a guide for the plasterer and a solid corner as well. The common sections of wooden corner-beads, and those usually carried in stock, are the first two shown in Fig. 346. A much better section, which holds the plaster and prevents its crumbling at the edges, is that shown at *B*. This is also about the only section that can be successfully applied to a brick corner. It may be made

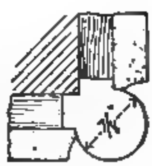


Fig. 346. Wooden Corner-Beads.

either ⅞ of an inch or 1⅛ inches thick, the latter thickness being best when the bead is to be used on brickwork.

The use of corner-beads varies in different localities. In the New England states they are quite common, but they appear to be seldom if ever used in the far-western states. They afford, however, the best protection for a projecting angle, and the author believes that it would be better if they were used more generally. The beads should be made of white pine, and should be perfectly straight and plumb. Since the introduction of metal corner-beads the wooden ones have been comparatively little used. (See, also, Art. 232.)

232. METAL CORNER-BEADS. Several types of corner-beads, made of rolled steel, have been patented and placed on the market. These are smaller than the wooden beads, make sightlier corners and are better able to hold the plaster at the angle so that it cannot crack or crumble away. As they can also be made perfectly straight, papering can be done better over them than over wooden beads. The superiority of one pattern over the others will probably be determined by its adaptation to practical use or by

Fig. 347. The Union Metal Corner-Bead.

the facility with which it can be applied. A few illustrations, taken at random, will show their general form, construction and application. Besides those illustrated there are a number of others of excellent make and efficiency. One type, which is shown in Fig. 347, is made of No. 24 rolled steel, perforated and cut into strips, bent on a die to the shape shown and then galvanized, the zinc coating soldering the sides together where they touch. This

bead is made in sizes for $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$ and $\frac{3}{4}$-inch grounds and in lengths of 6, 7, 8, 9 and 10 feet; it can be obtained bent to any radius for arches. It is shipped in bundles containing from 60 to 100 feet and weighing from 7 to 20 pounds, according to size and length. The cost of the bead varies from 4 to 5 cents per foot, according to locality. On woodwork it is secured by nailing with wire nails through the small holes in the flanges and can be put up as rapidly as a wooden bead. On brick, terra-cotta or other fireproof construction the beads are secured by means of short pieces of soft, 16-gauge, annealed wire, hooked to the bead and bent around the heads of fourpenny or fivepenny, cut nails, which have been driven at convenient places in the joints of the brickwork or tilework, from 3 to 6 inches from the corner and about 1 foot apart. When the grounds for wooden laths are $\frac{3}{4}$ of an inch, $\frac{3}{8}$-inch beads are required, as the plaster is $\frac{3}{8}$ of an inch thick; and when the grounds are $\frac{7}{8}$ of an inch, $\frac{1}{2}$-inch beads are required, as the plaster is then $\frac{1}{2}$ an inch thick. When $\frac{7}{8}$-inch grounds are used on woodwork the bead may be nailed over laths, as shown in Fig. 347.

Another type of metal corner-bead is shown in Fig. 348, which illustrates its use with short clips on wooden grounds. It is made also with long clips for use on brick or tile. These beads are made of steel, galvanized while hot, and will not rust. Their shape affords a good bond with the plaster, which by fastening itself about the head and back of them, forms a solid corner with no possibility of a "feather-edge." They are carried in stock lengths of 6, 7, 8, 9 and 10 feet and, if desired, they can be furnished in lengths up to 14 feet. One clip is furnished for every foot of bead and the clips are hot-galvanized like the beads. (See, also, Arts. 231 and 293.)

Fig. 348. The Parker Metal Corner-Bead.

233. INCLOSING THE BUILDING FOR PLASTERING. After the grounds and corner-beads are in place the building should be plastered. No finished work should be put up before plastering if a first-class job is desired.

Before the plasterers begin work the carpenter should close all outside openings by hanging temporary doors at the entrances and covering the window-openings with muslin or old sashes. If the

weather is not too cold muslin is the best material for closing the window-openings, as it allows a sufficient circulation of air to carry off the moisture produced by the drying of the plastering, without a decided draught. In very cold weather some of the openings should either be tightly boarded up or filled with temporary sashes. Old sashes, when available, are often used. Store-fronts should be boarded up on the outside, so that the fronts may be finished without removing the boards.

The architect should not allow permanent sashes to be put in until the building is plastered and dried out, as the moisture from the plastering would cause them to swell, and even if tightly fitted, they would become very loose after a time through shrinkage. Moreover, they would be more or less splashed with plaster and the stain so caused can never be entirely removed.

2. JOINERS' WORK.

234. GENERAL CONSIDERATIONS. Under the heading of "interior finish" is included all the finished woodwork used and put up inside of a building to form an integral part of it; this term also generally includes all work put up after the building is plastered. For distinguishing between finish that is affixed to the walls, such as casings, base-boards, wainscoting, beams, cornices, etc., and that which is not, such as cases, cupboards, drawers, shelves, etc., the former is often referred to as "standing finish," the latter as "fittings." Fittings or fixtures for stores, etc., are generally put in by the tenant, and are not usually included in the contract for the interior finish; but in dwellings everything necessary to complete the building for occupancy should be included in the specifications along with the standing finish.

As the primary object of the standing finish is to cover up the rough work and make a finish where the plaster joins the frames, or else to protect the plaster walls, an ornamental appearance is the chief requirement of the work; and to this end smooth surfaces, free from knots, sap or other defects, close joints and freedom from warping and shrinkage are more necessary than strength and durability.

235. FINISHING-WOODS. The cost and usually the character and quality of the inside finish depend greatly upon whether it is to be of "soft" or "hard" wood, and whether it is to be painted or varnished. As stated in Art. 6, Chapter I, the "softwoods" are classified commercially as those belonging to the conifers, the "hardwoods" as those from the broad-leaved trees. Carpenters, however, often classify whitewood or poplar, redwood and cypress as soft-

woods, and hard pine is frequently called a hardwood. Very frequently the term "hardwood finish" is used to distinguish all work that is finished in varnish from painted work, although the term "natural finish" is more accurate when any of the pines are used.

For finish of any kind the softwoods are always cheaper than hardwoods, even when the price of the lumber is the same. This is principally for the reason that the softwoods can be used "in the solid" for making doors, sashes, etc. The greater ease with which these woods can be worked also affects the price, although not to a very great extent.

The difference in the cost of casing a door in clear, white pine or oak is not very great, about 75 cents a side for 5½-inch casings; but when it comes to the doors, a veneered door (and veneering is necessary for most of the hardwoods) costs three or four times as much as a solid, pine door. Among the hardwoods, too, there is quite a difference in the cost of finishing, some of the hardwoods, on account of their scarcity, being very expensive (see Art. 76), while others, particularly ash and chestnut, have become cheaper than clear pine. Painted work also costs, as a rule, less than varnished work, for the reason that cheaper grades of lumber may be used; and the same care is not usually exercised in placing it and in keeping it clean.

For finish that is to be painted, the first consideration is that it shall "stand" well, and next to this are freedom from knots and pitch, and low cost. These conditions are now most fully found in the white pine, hard pine, basswood and cypress from the southern and eastern states and in the Douglas fir and hemlock of the north Pacific coast. Aside from the question of cost, white pine meets the required conditions in an ideal manner. Whitewood (yellow poplar, known also as "tulip poplar") is also extensively used in some localities, particularly for carved work, columns and mantels, and for shelving, etc., as it can be obtained in large dimensions and remarkably free from knots; its softness and uniform grain make it also well adapted for carving that is to be painted. This wood, however, does not stand as well as pine. In almost every locality hard pine is cheaper than white pine, but it contains too much pitch to take paint well. Spruce, also, is used to some extent for finishing, but it is inferior to soft pine, and the author cannot recommend it for any but the cheapest work.

For interior work that is to be stained or finished in its natural color, the color or grain of the wood most influences the selection when the cost is not a controlling feature.

Aside from the appearance of the wood, however, its hardness is a very important quality, as the softer woods mar easily, and so

greatly injure the appearance of the work. It is for this reason that soft pine, whitewood, redwood and cypress are inferior to oak, ash, beech or maple, although otherwise they make a very attractive finish when properly treated. Redwood, moreover, is very brittle, and the edges break easily.

In regard to their cost (1913), the various woods used for finishing rank in about the following order, commencing with the cheapest, the relative cost varying somewhat with the locality: whitewood, hard pine, fair white pine, cypress, chestnut, ash, redwood, red oak, white oak, beech, birch, maple, butternut, bird's-eye maple, cherry and mahogany.

Aside from the cost, the last eight woods are usually considered the handsomest and most desirable, although for certain rooms the other woods are nearly, if not equally, as well adapted. For public waiting-rooms and large rooms where a rich finish would hardly be expected, cypress and hard pine are very appropriate and much used.

Ash is quite extensively used in churches and large buildings, as it is cheaper than oak but it cannot be used for solid doors as it will not stand. In dwellings all of the woods mentioned are more or less used, hard pine, for varnishing, being frequently used in the kitchen, servants' quarters, etc., and the other woods as the taste and means of the owner dictate or permit. Where a showy but cheap, natural finish is desired, whitewood stained in imitation of cherry is often used. Ash is frequently stained in reds and greens for the color-effect, and the oaks are usually colored slightly in the filling-coat. Ash, chestnut and oak can be colored or stained with ammonia so that they will very closely imitate old oak.

The other woods are generally finished in the natural color, although the oil or varnish gives most of them a deeper tone.

The characteristics and qualities of the various woods have been described in Chapter I.

All hardwoods and all softwoods that are to be varnished should always be kiln-dried just before they are sent to the building (see Art. 13). It is desirable that all of the inside finish should be kiln-dried, but it is not the general custom to kiln-dry woods that are to be painted.

The various woods to be used in finishing the different portions of the building should be explicitly specified by the architect before he describes the character of the finish.

Except occasionally in wainscoting and in inlaid work, all the exposed finish in a room, including the door-frames and doors and the inside of the sashes, should be of the same wood. (See, also, Arts 28 and 29.)

236. JOINERS' WORK AND CARPENTERS' WORK. A large portion of what formerly constituted "joiners' work" is now done at the mills or woodworking-shops, so that the joiners' trade as distinguished from the carpenters' is now confined, at least in this country, to those who work at the cabinet-maker's bench or in the shop. The carpenters, as a rule, do that portion of the work that has to be done at the building, such as smoothing and cleaning, joining and putting up the work. The stairs usually are built by a separate class of workmen.

237. PLANING, SMOOTHING AND POLISHING INTERIOR WOODWORK. All moldings, except in rare instances where a small quantity and a special pattern are required, are now "run" or "stuck" by machinery at a molding-mill, and all planed surfaces are usually mill-planed. Molding and planing by machinery is usually done by revolving knives, under which the work is drawn by fluted cylinders whose edges, in order to obtain a firm grip of the piece, press so strongly against it as to cause slight transverse indentations on the prominent portions, which injure its appearance very seriously, unless the marks are subsequently smoothed off. Planed surfaces, also, often have small ridges running parallel with the grain, and the surface is rough, especially with the harder woods.

In very cheap work the finish is put up as it comes from the machine, with the indentations and rough surfaces; but for buildings in which a good finish is desired, the specifications should require that all finishing-lumber be smoothed and sandpapered before it is put in position. Unless this is specified, the carpenter may refuse to do it.

In the case of moldings, the smoothing is usually done with sandpaper, although the raised flat surfaces should be smoothed with a plane. All planed surfaces, such as the face of bases, casings, beaded ceiling, etc., should be smoothed with a smoothing-plane, and the hardwoods should be scraped with a piece of hard steel made for the purpose.

Most of the large woodworking-establishments have machines which polish the planed surfaces by passing them between steel rollers, one of which is covered with fine sandpaper. Work finished in this way is superior to that smoothed by hand; but very little polished work is sent to the building, except that which is worked or put together at the shop. Paneled work, stair-work, cases, mantels, etc., are generally made at a shop, and such work is always smoothed before being put together.

238. JOINTS IN INTERIOR WOODWORK. A very important requirement of interior finish is that the joints shall be as

tight and inconspicuous as possible; and, in fact, it was in the character of the joints, the smooth surfaces and the smaller dimensions of the pieces that the distinction between "joinery" and "carpentry" arose.

The various joints made in connecting interior finish and fittings may be classified under one or more of the following kinds: butt-joints, tongued-and-grooved joints, splined joints, mitered joints, coped joints, covered or housed joints, glued-and-blocked joints and dovetailed joints; and the work is said to be butted, matched, mitered, coped, housed or rebated, glued-and-blocked, or dovetailed, according to the kind of joint that is made. Very frequently two of these operations are combined in a single joint. (See the following Figures and, also, Fig. 489.)

239. BUTT-JOINTS. A butt-joint is made by simply butting one piece against the other, as at *A* and *B*, Fig. 349. Though this is the easiest joint to make, there is this objection to it, particularly in varnished work, that any shrinkage in the board *b*, or in either or both of the boards at *B*, will cause the joint to open, as shown by dotted lines, and of course the greater the width or thickness *d*, or the wider the boards in *B*, the greater will be the shrinkage.

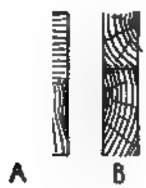


Fig. 349. Butt Joints.

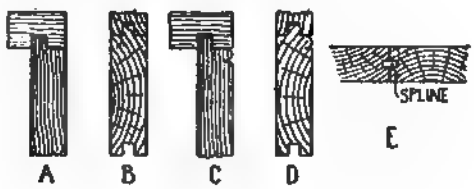


Fig. 350. Tongued and Grooved Joints.

Another objection to this joint is that it is difficult to keep the surfaces joined in exactly the same plane; and further, when casings are joined, as at *A*, the end-wood is exposed on the side. The last objection can be overcome by placing a "back-band" around the outer edge of the casings.

The principal instances in which butt-joints are used in interior finishing are in joining plain or so-called "ogee" or "O. G." window-casings, and in using "block-and-pilaster" finish. (See Figs. 395 and 405.) The butt-joint is also used in flooring.

240. TONGUED-AND-GROOVED JOINTS. This is a form of butt-joint in which one surface or edge is grooved, while the other has a tongue worked on it to fit into the groove, as shown at *A* and *B*, Fig. 350. The chief object of the tongue and groove is to keep the surfaces joined flush with each other. The tongued end also prevents the board from warping and in case of shrinkage pre-

vents dust from passing through, but does not prevent the appearance of an open joint. To overcome the bad effect produced by shrinkage, a bead is often worked next to the tongue, as in *C* and *D;* the joint then has the same appearance as the "quirk" on the other side of the bead, unless the shrinkage is very great. Boards tongued and grooved, as at *B*, are called "matched" boards, and when beaded are called "matched-and-beaded"; if there are two beads they are "double-beaded," and if there is a bead at the center they are "center-beaded." The tongue and groove is extensively used in flooring and sometimes in sheathing, while the matched-and-beaded joint should be used for ceiling.

241. SPLINED JOINTS. A splined joint is practically the same as a tongued-and-grooved joint, except that both edges are grooved, and the tongue or "spline," as it is called, is made of a separate piece, as at *E*, Fig. 350. Splined joints are not as frequently used as the tongued-and-grooved; in joining very thick stuff, however, as 3 or 4-inch planking, the spline is more economical of material, and in making a very fine joint it is superior to the tongue-and-groove.

242. MITERED JOINTS. A mitered joint is made by beveling the parts joined so that the plane of the joint bisects the angle. It is used in making the angles of bases, all horizontal moldings, fine

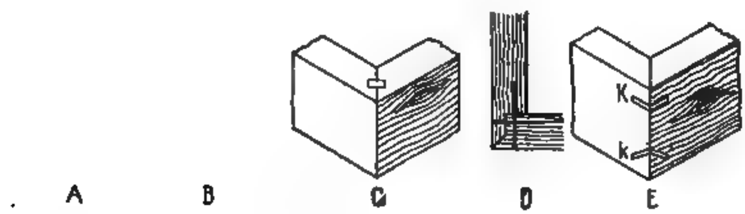


Fig. 351. Miter-Joints.

wainscoting, etc.; in fine cabinet-work; and in making the angles where moldings are carried around openings.

With a true miter all parts of the moldings intersect perfectly, as at *A*, Fig. 351.

When skillfully done the miter makes the handsomest joint, and in many places, as with panel-molds, it is the only joint that is practicable. A mitered joint, however, has the disadvantage that any shrinkage in the wood causes the joint to open at the inner edge, as shown at *B*, where the dotted lines show the pieces when first joined, and the full lines show the pieces after they have shrunk. It is not uncommon to see door and window-casings that have shrunk so as

to open the joint a quarter of an inch. This, of course, looks very bad, and hence the mitered joint should only be used when the wood is thoroughly kiln-dried and not allowed to swell afterwards, as no mechanical device will prevent wood from shrinking.

Mitered Joints for Bases, Wainscoting, Built-Up Posts, etc. In the cheaper grades of work the pieces are simply mitered and glued or nailed together. Such a joint is not very strong, as the glue does not hold very strongly on the end-wood, and neither do nails. When a plain miter is used in cabinet-work, the edges should be grooved and a hardwood dowel should be glued and driven in, as at *C*, Fig. 351.

A still better joint is that shown at *D*, a rebated, nailed, mitered joint. In such a joint the parts can be securely nailed from both faces, and portions of the joint are parallel with the grain. When internal angles are mitered and glued before they are put up, the joint may be strengthened by inserting thin strips of hardwood, called "keys," in the back of the joint, as shown at *E*. These may be either horizontal, as at *K*, or inclined, as at *k*, the latter being the stronger. All of these joints, slightly modified, are applicable to acute and obtuse as well as to right angles.

For first-class work all mitered joints should be glued and further strengthened by dowels, blocks or brads. Mitered joints for casings are described in Art. 261.

243. COPED JOINTS. A coped joint is only used in connection with moldings; it is made by cutting the end of one molding to fit the profile of the other, as in Fig. 352. When nicely made a

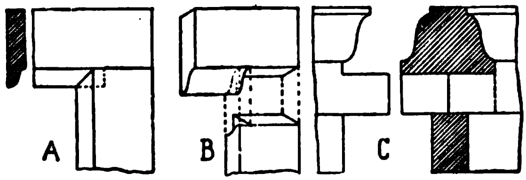


Fig. 352. Coped Joints.

coped joint cannot be distinguished from a mitered joint, that is, if the moldings are alike and not too elaborate. When one molding comes against another of a different pattern, the one which is stopped should be coped to the other.

Sash-bars or muntins, the rails and stiles of sashes and of solid, molded doors and paneling, ogee casings, etc., are usually coped.

A coped joint has the advantage over the mitered joint in that any shrinkage in the piece that is coped does not open the joint, and if the other piece shrinks the joint does not open as badly as with a

mitered joint. Only comparatively plain moldings, however, can be successfully coped.

244. COVERED JOINTS AND HOUSED JOINTS. The author has used the term "covered" joint to designate those joints in which the edge of one part laps over onto the face of the other, usually from ⅜ to ½ of an inch.

When two pieces of finish are joined parallel with the grain a covered joint should be used when possible, as it permits the parts to shrink moderately without opening the joint. The joint is usually made by rebating or ploughing the edge of the projecting piece, as at *A* and *B*, Fig. 353. Rebated or ploughed joints are always used in making paneled work, and with raised moldings, back-bands, etc.

A "housed" joint is one in which the end or edge of one piece is wholly let into the side of the other, as at *C*, Fig. 353. Housed joints are used principally in joining the ends of stair-treads and risers to the wall-string, and to a closed string, and in uniting the

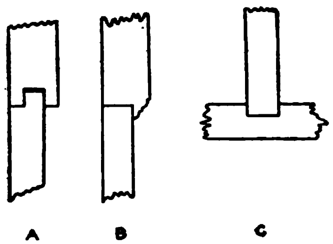


Fig. 353. Rebated Joints.

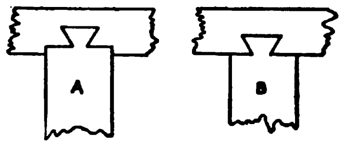


Fig. 354. Dovetailed Joints for Re-entering Angles.

angles of cisterns and tanks. It makes a strong as well as a neat joint for such places. A grooved or ploughed joint like that at *A*, Fig. 350, is sometimes called a "housed" joint, but the author prefers to confine the latter term to a joint like that at *C*, Fig. 353.

245. DOVETAILED JOINTS. A "dovetail" is a tenon or pin, made in the shape of a truncated wedge, the outer end being the wider, as shown in Figs. 354 to 357. Such a tenon, when fitted into a mortise or groove of corresponding shape, obviously cannot be drawn out without shearing the wood; hence a dovetailed joint is very strong, irrespective of glue or nails. Dovetailing, however, is seldom used in joining standing finish. It is confined principally to fittings, cabinet-work and furniture. Still there are places in other kinds of work where the dovetail makes the best joint and should be used in preference to others.

Details *A* and *B*, Fig. 354, show dovetailed joints suitable for re-

entering angles in joiners' work. That at *A* is also used for securing the balusters of stairs to the treads.

Fig. 355 shows the "common-dovetail" joint for external angles. This is the strongest joint, but is not used in cabinet-work, unless the pin-ends showing on the face can be covered with a molding.

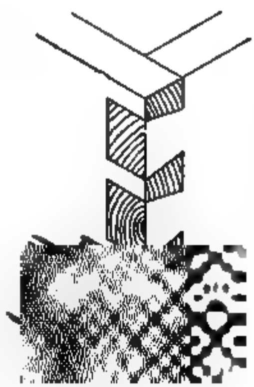


Fig. 355. Common Dovetailed Joint.

The joint shown in Fig. 356 is called a "lapped dovetail," because the front laps over the ends of the pins so that they do not show on the face. This makes nearly as strong a joint as the common dovetail, and is largely used in uniting the front and sides of drawers.

For highly finished drawers and boxes the "mitered dovetail" or "secret dovetail," shown in Fig. 357, is sometimes used by cabinet-makers. Only one of the boards to form the angle is shown in detail; the other is made to fit the projections and indentations of the one shown. When put together this joint has the appearance of a mitered joint, but as the dovetails have only one-half as much holding-surface, it is only about half as strong as the lapped dovetail, and the latter is to be preferred for large drawers. Dovetailed joints in joinery are always glued.

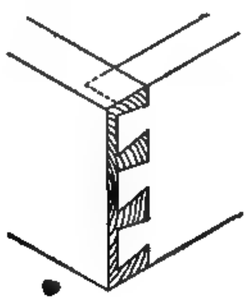


Fig. 356. Lapped Dovetailed Joint.

Fig. 357. Secret Dovetailed Joint.

246. GLUED-AND-BLOCKED JOINTS. Many joints in joinery and cabinet-work are made by gluing the connecting parts together, and also gluing blocks of wood into the reentering angle, as in Fig. 358, to further strengthen the joint and preserve the shape of the angle. Such work is said to be "blocked-and-glued," and as long as the glue holds it makes a strong joint.

For all sorts of curved surfaces small blocks are glued together and then covered with a veneer, or sometimes the wood is bent to the form required and blocks are glued to the back to keep it so.

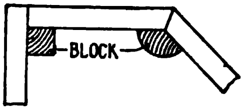


Fig. 358. Glued-and-Blocked Joint.

Glue is also used by itself to connect the edges of boards in making one wide board, and when the grain of the wood is carefully matched the joint can hardly be detected. If the boards are thoroughly dry and a good quality of glue is used, the joint will be as strong as the solid wood. Such joints, however, sometimes come apart through continual changes in temperature and humidity, or because the wood was not thoroughly dry; so that it is always best to strengthen them by dowels, or by a tongue-and-groove. Glue is very extensively used in the best grade of joinery and in cabinet-work, but it is best not to depend upon it entirely, except in the case of veneers, etc.

247. FRAMED FINISH. MORTISE-AND-TENON JOINTS. All large pieces that are free to warp and twist, such as doors, shutters, sashes, etc., and interior panel-work of every kind, should be "framed" together by making a frame of boards running parallel with the outside edges of the work. The space enclosed by the "frame" is usually filled with panels made of wood or glass. Wood panels may be set flush with the frame or sunk, as preferred. When the piece is very large, exceeding 2 by 3 feet, the frame should be divided into two or more panels by cross-pieces framed into the outer pieces. As the boards or planks used in forming the frame are usually not more than 6 inches wide, and often not more than 2 or 3 inches, the size of the frame is but little affected by shrinkage. The shrinkage that would naturally occur in so wide a piece is taken up by the panels, which should be so arranged that the effects of shrinkage or swelling will not be apparent. Framed work is also less likely to warp than any other arrangement of pieces, because the grain in the different parts of the frame runs in different directions. The greater the number of panels, the less is the liability to warp.

The pieces forming the frame should always be joined by mortising and tenoning, which is similar to the same operation in carpentry, except that it has to be done with greater care and neatness.

The tenons should have a thickness from one-fourth to one-third that of the frame, and the breadth should be about two-thirds of the breadth of the piece, but no single tenon should be more than 4 inches wide, as a broad tenon may shrink considerably and become loose, besides necessitating a wide mortise, which might weaken the frame. Hence when the wood is wide, say over 7

inches, a double tenon should be used, as at *B*, Fig. 359. This drawing also shows a "haunch" on the tenon, which is seldom used, however, except in the very best work.

When the mortise comes at the end of a stile or rail the tenon is usually cut as at *A*. The piece containing the mortise should be left long, as shown by the dotted lines, and not cut off until the glue is hard.

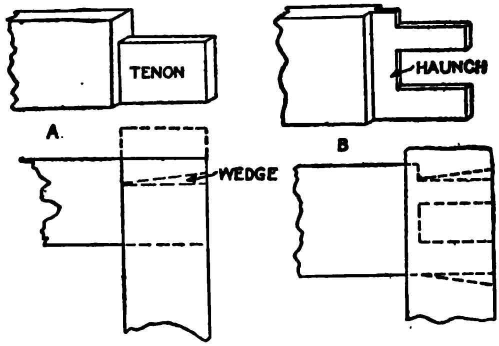


Fig. 359. Mortise-and-Tenon Joints.

The tenon should be secured in the mortise by wedging and gluing, as shown by the dotted lines, the mortise being cut a little large to accommodate the wedges. In cheap doors the tenons are often secured by pins which show on the face, but this method of fastening is inferior to the wedged joint.

248. DOWELED, KEYED AND SPLINED JOINTS. When plain surfaces of boarding of considerable extent are required for wainscoting dadoes, etc., they should be built up of narrow boards, from 3 to 4 inches wide, carefully jointed, doweled and glued together edge to edge, and keyed on the back by tapering pieces of kiln-dried, hard, wood let into a wide dovetailed groove, as shown in Fig. 360. These keys keep the surface of the boards in the same plane and allow the work to shrink and expand with changes in the humidity of the air of the room. They should be driven tight but not glued. In fitting the boards together they should be so placed that the direction of the annual rings in each piece is reversed.

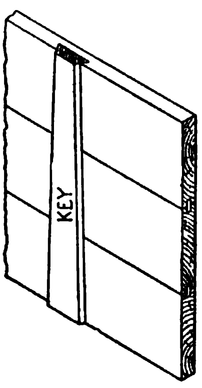


Fig. 360. Splined and Keyed Joints.

Very often the edges of the boards are grooved and a hard-wood strip or "spline" is let in the whole length to strengthen the joint; but dowels are superior to this device for the reason that a groove leaves a thin tongue of wood on each side of the board, which is liable to curl and thus cause the joint to open, as in Fig. 361. When dowels are used no such defect is likely to occur,

as the edges of the boards are not cut except at intervals where the dowels are placed, and then only by holes just large enough to receive them.

When it is desired that a dado shall appear like one wide board of hardwood, a backing of pine should be glued up, as described above and the face then covered with a thin veneer of the finished wood. In the very best work two thicknesses of veneering are used, as described in Art. 285.

Fig. 361. Splined Joint, Opening.

Occasionally doors are designed to appear as if made of a single plank of wood, generally of some expensive hardwood. To obtain this effect and at the same time have a door that will not warp, the door must be framed and filled with flush panels and then veneered with two thicknesses of very fine veneer, as described in Art. 257.

249. SCRIBING. This is the operation of bringing the edge of a piece of wood, usually a long strip, to fit close to an irregular surface, as in fitting the edge of a board to a plastered wall that is not a true plane, or to rough stonework. It is done by placing the board so that it will be parallel to its intended position and as near to the irregular surface as convenient, and then setting a carpenter's compass so as to cut off just enough to give the proper width to the board; one point is drawn along the irregular surface while the other is made to scratch a line on the face of the board, as shown by the dotted line, Fig. 362. This line will, of course, be exactly parallel to the profile of the surface, and when the board is cut it will fit exactly in position.

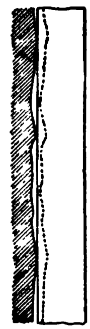


Fig. 362. Scribing.

250. PUTTING UP THE FINISH. This is the last operation performed by the joiner, and as it varies with different kinds of work, it will be described in connection with the finish.

251. MOLDINGS. 1. *General Considerations.* Although the moldings used in connection with the interior or exterior finish of the better class of buildings are usually made in accordance with the architect's full-size details, and hence are seldom exactly alike in any two buildings, yet there are certain shapes that are so commonly used as to have specific names, and class-names have been given to moldings used for particular purposes, irrespective of the shape of the members. As these names are in common use among builders and architects, and are often used in the specifications, it

seems advisable to define them before entering upon a description of the finish.

2. *Names of Moldings.** In Fig. 363 are shown sections of moldings that are used with so little variation as to have a name. These moldings may vary in size,† but the shape is always practically the same. For every molding shown in section or profile in this figure, there is a name printed either under or on the molding itself.

Most of these terms require no further explanation. The "quirk" is not a molding proper, but is the little groove formed at the side of a molding, sunk a little below the surface, and used most commonly with the "bead" or "torus." Beads are extensively used in

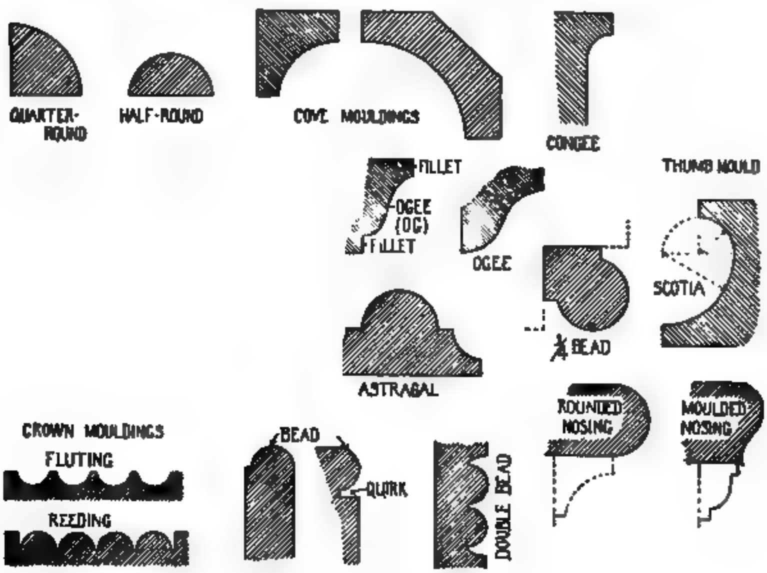


Fig. 363. Moldings Used in Interior Finish.

interior finishing, often with the quirk, to conceal a joint. When several of them are used together in the center of a board they are called "reeding." The term "fillet" is used to designate a narrow, flat surface, usually not more than ⅜ of an inch wide, on each side of a molding or between moldings. Fluting may have either rounded or square "channels," the rounded being generally understood. Molded "nosings" may be of almost any shape, but are

* All of the moldings used in connection with the "five orders" of architecture have specific names, but some of them are practically obsolete with builders, and only such names are given here as are in common use.

† The moldings shown in Figs. 363 and 365 are drawn from one-third to one-half the more common size.

generally rounded on top. Besides these names, which indicate the shape of the molding, there are also two terms, "solid molding" and "sprung molding," which apply to moldings of different outlines.

A "solid molding" is one in which the wood fills the space behind the molding proper, usually to a right angle. A "sprung molding" is one worked from a board or thin piece so that the back is parallel to a line tangent to the face. When such a molding is

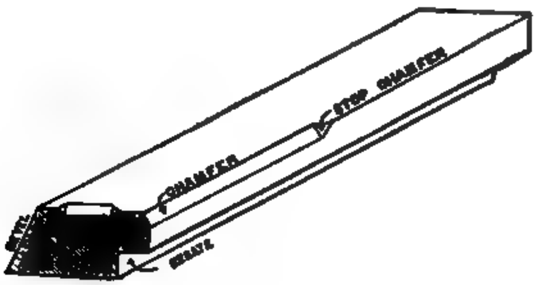


Fig. 364. Bevel, Chamfer and Rebate.

set in its proper position against a board there will be a space behind it. The crown-moldings and the larger cove-moldings shown in Fig. 363 are sprung moldings, while the others are solid moldings. Bed-moldings (see Fig. 365), unless quite small, are

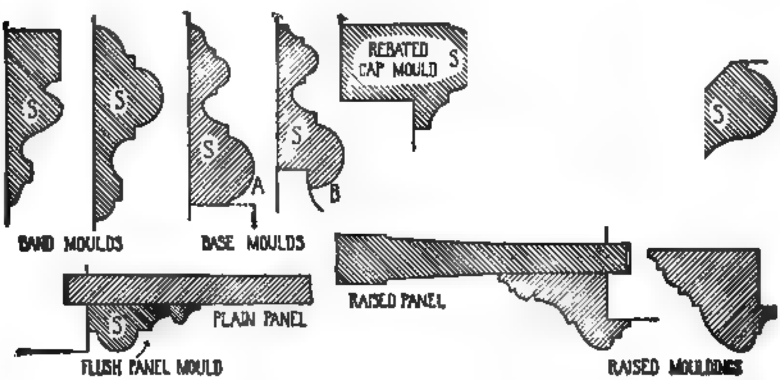


Fig. 365 Moldings Used in Interior Finish.

usually sprung moldings. Besides moldings proper, there are also the "bevel," "chamfer" and "rebate," shown in Fig. 364, that are extensively used in joinery.

3. *Kinds of Moldings.* There are different moldings used for different and distinct purposes; they may, and usually do, vary

much in their profile, but the general shape is usually about the same for each kind of molding. Those terms which are generally recognized by carpenters and millmen are illustrated in Fig. 365.

A "band-mold" * is one that is nailed or glued to the face of other parts of the finish. A "bed-mold" is one used in the angle formed by a soffit with a vertical surface. "Raised moldings" are used principally in connection with panel-work and are almost always of the general shape shown. Flush-panel moldings are made in a variety of patterns, but one with a quirk next to the stile or rail is best, as it will not show the effects of slight shrinkage.

The "base-mold," *A,* square at the bottom, may be used when a plain board is used for the base. If the base is molded a rebated base-mold is preferable. Base-molds should be comparatively thin at the top so that they may be sprung to fit the plastering if the latter is not perfectly straight.

Moldings are said to be "planted on" when they are nailed or glued to the face of a wider molding or board. Band-molds are always planted on. The term "stuck molding" is sometimes used to designate a molding that is worked on the edge of a board or plank, but the word "stuck" more commonly refers to the making of the molding, that is, to its passage through the machine.

4. *Stock Moldings.* A great many moldings are carried in stock by the larger lumber-dealers. Books published by manufacturing companies give full-size sections of the moldings usually kept on hand.

Most of the moldings shown in Fig. 363, and those marked *S* in Fig. 365, are stock moldings. When only small quantities of moldings are needed it is cheaper to use stock patterns, which can usually be made to answer for the exterior finish of moderate-priced houses. The speculative builder uses them altogether, as a rule For the interior finish and on the exterior of the better class of buildings the architect usually prefers to design the moldings himself, and in such case he should specify that "all moldings are to be stuck according to the full-size details."

5. *Price of Moldings.* Moldings are universally sold by the linear foot, the price for the same wood varying with the number of square inches in the cross-section of the piece from which the molding is worked.

Hence in writing specifications for estimates, if the full-size details are not to be furnished at that time, the architect should specify the size of the wood from which the various moldings are

* The term "mold" for molding is here used because it is almost universally used by mechanics when a prefix is added.

to be worked, and the contractor can then estimate as accurately as if he had the profile, as the profile does not usually affect the cost. When several moldings are used together each piece is called a "member," and the number of members with the size of each should be specified.

Almost any molding that the architect chooses to design can be made by machinery, but those which are "undercut" are more difficult to work than those which are not.

252. DETAILING THE FINISH. As most of the individual moldings with which interior finish is ornamented are usually quite small, they can be properly shown only by full-size details. To study the relation and proportions of the parts, drawings made to a scale of ½ or ¾ of an inch to the foot, usually called "scale details," are of the greatest assistance, and in the case of elaborate work, such as staircases, mantels, sideboards and other fittings, quite indispensable. As a rule the architect will obtain the best results with the least labor by drawing all special finish to one of the scales above mentioned and then showing the profile of the moldings by full-size sections, without attempting to draw the entire object full size. All important dimensions should be indicated in figures on the scale details the same as on a plan. All carving should also be drawn full size, but where it is symmetrical but one-half need be shown.

Nearly all work that is built in or made a part of the building has to be made to fit the constructional portions, and as these usually vary slightly from the plan, even when the work has been very carefully done, it is customary for the person who is responsible for the proper execution of the finish to make careful measurements of the building after the grounds are set, and from these measurements to lay out the work, if it is to be put together at the shop, full size, making it as nearly as possible like the architect's drawings, but fitted exactly to the place where it is to go. Thus it is seldom that elaborate work is put together directly from the architect's drawings, although when completed it may appear so; and hence much time is often wasted by the architect or his draughtsmen in making drawings that, except for the sections, are of no practical use.

Moldings, however, are usually made exactly in accordance with the architect's sections, the knives being set to fit the drawings, and drawings for turned work are usually carefully followed; hence the necessity for care in making such drawings.

In making the full-size sections the draughtsman usually has first in mind the effect that will be produced by their shades and shadows, as it is these alone that give values to the moldings; but

it is of fully as much importance to design the work so that when put together its appearance will not be spoiled by the first shrinkage or swelling that takes place, and this it must be remembered cannot wholly be avoided in woodwork. Methods for overcoming the effects of shrinkage will be considered in describing the finish, but the following general rule for good joiner's work should always be kept in mind, namely: always use narrow boards in place of wide ones, and wherever practicable always fix the work so that it will be free to expand or contract. Open joints and split panels or boards spoil the appearance of the finest work and injure the reputation of the architect.

The experienced architect or draughtsman may also do much to keep down the cost of the work by so drawing his moldings as to require the least amount of material without any sacrifice of appearance. Nearly all of the finishing-woods are sawed to thicknesses of ½, ¾, 1, 1¼, 1½ and 2 inches. When dressed on both sides they lose ⅛ of an inch in thickness, and when run through the molding-machine or planer their thickness is again reduced by about 1/16 of an inch; so that all molded members should be drawn either 5/16, 9/16, 13/16, 1 1/16, 1 5/16, or 1 11/16, inches thick to utilize the wood economically. The nominal size of moldings is that of the rough lumber; for example, "inch-stuff" when worked into moldings is actually but 13/16 of an inch thick, although it is charged at the rate of 1 inch. In the same way a 6-inch board is usually ¼ of an inch narrower, and stock casings are often measured ½ an inch wider than their actual width.

3. DOORS, INSIDE-DOOR FRAMES AND FINISH.

253. PLACE OF DOORS IN THE CLASSIFICATION. These are not always classed as a part of the interior finish, but they form a very important part of the interior woodwork and often give more trouble than the standing finish.

254. BATTENED, LEDGED AND BRACED DOORS. Fig. 367 shows four types of doors used plain in rough construction, such as cellar, board-partitions, etc. The drawings illustrate the "framed-and-ledged" door, the "framed-and-braced" door, the "ledged" door and the "ledged-and-braced" door. Fig. 366 shows at *a* a solid, battened door made of two thicknesses of ⅞-inch matched boards, laid diagonally, with the boards on one side laid at right-angles to those on the other. This type of door is often used for the foundation of metal-clad fire-doors. Type *b* is a battened door made with a framed-up core, a better method of forming a battened door than type *a*, but more expensive. Some-

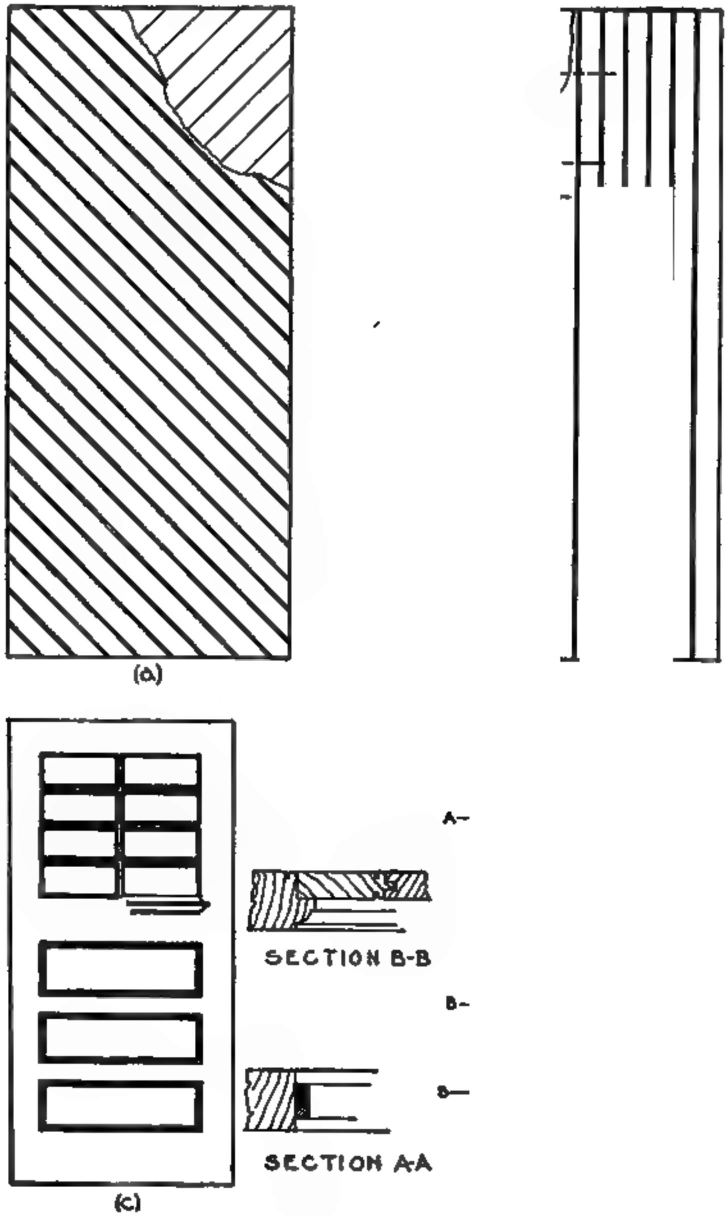


Fig. 366. Battened Doors. Entrance-Door. Box-Stall Door.

times doors of this type are paneled on one side and battened on the other. At *c* one type of entrance door is shown. Type *d* is a door for a box stall in a stable and is made unusually heavy and

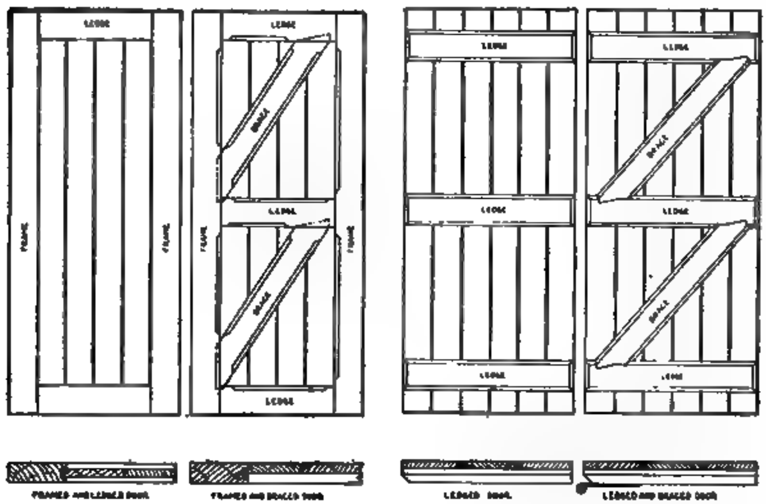
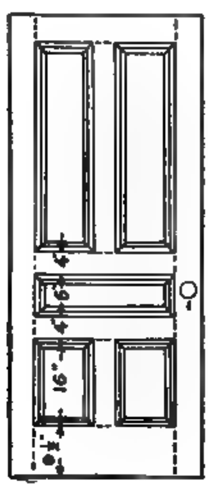


Fig. 367. Ledged and Braced Doors.



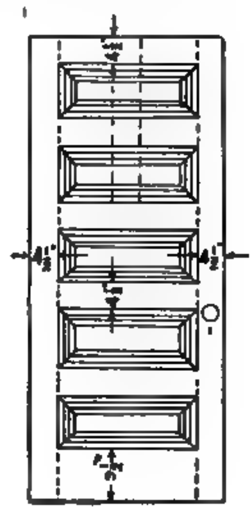


Fig. 368. Eastern, Stock, Four-Panel Door.

Fig. 369. Five-Panel Stock Door.

Fig. 370. Five-Panel Stock Door.

strong. Fig. 371 shows various types of inside and outside doors. Types *a, d, e, f, g, h* and *i*, are for inside doors; *a* and *d* are per-

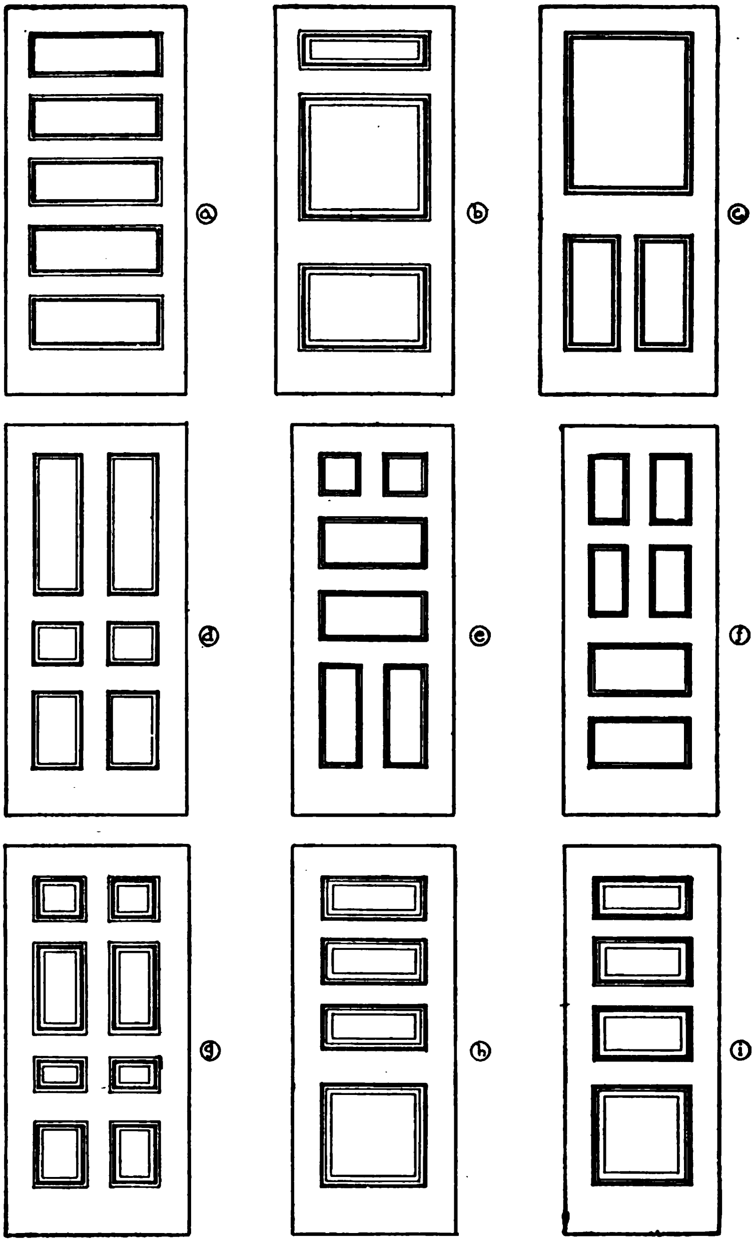


Fig. 371. Types of Interior and Entrance Paneled Doors.

haps the most common. Types *b* and *c* are for outside or entrance-doors. The latter, which is the commoner of the two, is glazed in the upper panel.

255. STOCK DOORS. 1. *Materials Used in Stock Doors.* In houses costing less than $4,000 it is generally necessary to use "stock doors." These are made of white pine, Douglas fir, veneered birch, veneered brown ash, veneered oak, and sometimes of whitewood, of certain regular sizes and thicknesses, and are always kept in stock by lumber-dealers. Cypress doors of different designs are also carried in stock in some eastern cities.

Three qualities of stock doors are usually kept on hand, namely, A, B and C; the A doors, which are the best, being of clear stock and usually well made. B doors contain a few small knots, and perhaps some sapwood, but will answer for common painted work. C doors should never be specified, as they are unsuited for any but the cheapest class of work.

There are differences in the construction of different stock doors. The better class of doors have the tenons glued and *wedged,* as in specially designed work, while doors of a cheaper kind are merely glued and pinned with wooden dowels which show on the face.

As stock doors are kept on hand in a storehouse for some time it is impossible to keep them thoroughly dry, so that they are quite sure to shrink when subjected to furnace heat; and if made of whitewood they are also quite liable to warp or "spring."

2. *Size and Thickness of Stock Doors.* Stock doors are made 1⅛, 1⅜ and 1¾ inches thick. The first are sometimes used for closet-doors, but the 1⅜-inch thickness is generally used for all inside doors less than 3 feet in width and 7 feet in height. Sliding doors, however, as well as all doors 3 feet or over in width or exceeding 7 feet in height, and all outside doors should always be at least 1¾ inches thick. The sizes of stock doors vary from 2 to 3 feet in width and from 6 feet 6 inches to 7 feet in height; they are always made in even inches. The height in inches, above 6 feet, is seldom made less than the width in inches above 2 feet; thus doors 2 feet 8 inches by 6 feet 6 inches or 2 feet 10 inches by 6 feet 8 inches are not usually kept in stock.

3. *Construction of Stock Doors.* Stock doors are as a rule divided into four panels, as shown in Fig. 368, and in the eastern and middle states, may be obtained with plain or raised panels, flush or raised moldings, as desired. A four-panel door answers very well for sizes not exceeding 2 feet 10 inches by 7 feet, but for larger sizes it is hardly stiff enough. Five-panel doors, divided as shown in Fig. 369, are also kept in stock. These are good,

strong doors, well suited for a large variety of buildings of a public nature.

An objection to the ordinary four-panel door, shown in Fig. 368, is that the middle rail comes at the same height as the lock, so that the mortise for the latter cuts away a large part of the tenon, and thereby weakens the door. In a door paneled as in Fig. 369 the lock comes opposite the middle panel and hence does not weaken the door to the same extent.

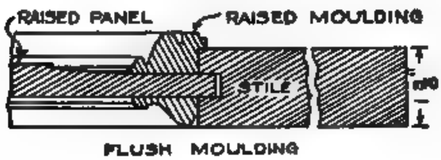


Fig. 372. Setting of Panel in Stock Door.

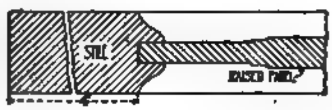


Fig. 373. Section of "O. G." Stock Door.

The rails of a door are always tenoned into the outer stiles, which extend the full length of the door, and the middle stile is tenoned into the rails. The stiles should always be of the proper width to allow for the use of locks with regular "backsets." Special backsets add to the cost and cause delay in filling orders. The panels are set in as shown in Fig. 372, which shows a raised panel and molding on one side and a plain panel and a flush molding on the other side. The

Fig. 374. Detail of Stock Sliding Door.

moldings are usually fastened in place by small nails or brads, which should not penetrate the panels.

4. *Ogee or O. G. Stock Doors.* The stock doors commonly sold throughout the West do not have a separate panel-mold, but an ogee molding is worked on the edges of the rails and stiles, as shown in Fig. 373; hence these doors are commonly called "O. G,

doors." They are a little cheaper than the molded doors, but less desirable, because the panels are not held so securely, and sometimes shrink, so as to draw out of the groove. (See, also, Fig. 386.)

In most of the larger cities several patterns of "front doors" are carried in stock which answer very well for cottages, but are seldom good enough for a house costing over $2,500.

5. *Stock Sliding Doors.* When a stock door or other door is to be used as a sliding door, a meeting-molding, similar to that shown in Fig. 374, should be glued and bradded to the meeting-edges of the doors and a small molding, corresponding with the projecting portion of the meeting-moldings, should be carried

Fig. 375. Astragal Molding for Meeting-Rails of Outside Double Doors.

Fig. 376. Astragal Moldings for Heavy Outside Double Doors.

across the top and down the back of the door. These moldings fit against the jamb and prevent the face of the door being scratched. The tongue and groove on the meeting-molding may be either beveled or curved, as desired.

6. *Stock Double Doors.* These doors are hung with butts and often have the meeting-rails rebated. This does well for inside doors but for outside doors it is better to screw an astragal or "weather-molding" to the edge of the standing part, as shown in Fig. 375. This protects the joint from the weather and also holds the doors more firmly together. If the doors are very heavy an "astragal" should be screwed to each of them, as shown in Fig. 376. These suggestions apply either to stock doors or specially designed doors.

256. SPECIALLY DESIGNED DOORS. These include all doors that are made to order from the architect's drawings. They should be made of stock that has been well air-seasoned and thoroughly kiln-dried, and, if a hardwood finish is required, it should be veneered on a pine core. The specifications should describe all

particulars of their manufacture, and 1-inch or ¾-inch scale-drawings should be made, with the width of the stiles, rails and panels carefully figured. All moldings and ornamental work should be drawn full size.

"Solid" doors are usually made in much the same way as stock doors, except that more care is taken with them, and they are kept perfectly dry. If the architect wishes to have the doors made in

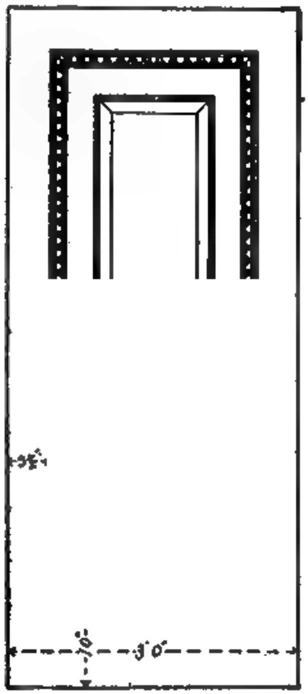


Fig. 377. Single-Panel Door for Inside or Outside Use. (See Fig. 382.)

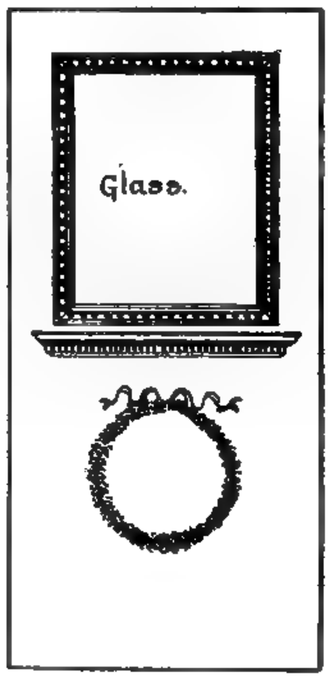


Fig. 378. Outside Door. (See Fig. 385.)

the best manner, he should require that the tenons be made with haunches, as shown in Figs. 359 and 380, and that the panels be put in without bradding or gluing, as described in Art. 257.

When the doors are made to order the panels may be arranged as desired, although the cost of a door depends largely upon the number of panels. For solid doors, and for ordinary veneered doors, an arrangement of panels like that shown in Fig. 370 is very satisfactory, as it makes a very strong, well proportioned door the panels of which are not so wide as to cause excessive shrinkage.

The two upper panels may be reversed, as shown by the dotted lines, if desired.

Fig. 377 shows a door with but a single panel, which may be used either as an inside door or as a front door. (See Fig. 382 for detail.) Figs. 378 (see Fig. 385 for detail) and 379 (see Fig. 383 for detail on line *A B*) show two designs for outside doors, the latter of which is cut in two horizontally, so that it is really two

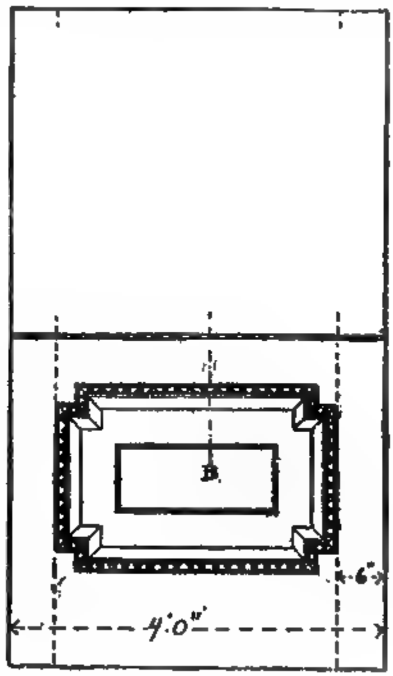


Fig. 379. Outside "Dutch" Door. (See Fig. 383.)

doors. This style of door is usually called a "Dutch door." Doors with panels over 12 inches wide must be made with much more care than doors with narrow panels. The thickness of doors with large panels, such as are shown in Figs. 377 and 379, must be at least 2 inches for doors 3 feet 4 inches wide and under, and 2¼ inches for doors over that width.

257. VENEERED DOORS. Doors which are to show hardwood finish should be constructed as shown in Fig. 380, or according to some approved variation of this general method, and pine or other softwood doors intended for a finely finished room, should be made in the same way. The stiles and rails are made by sawing

⅞-inch clear-pine boards into strips as wide as the door is to be thick, less ½ an inch, and carefully gluing them together, face to

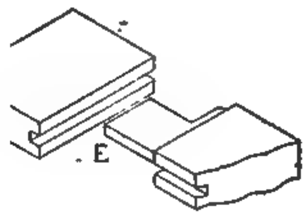


Fig. 380. Details of Construction of Veneered Door.

face, until the width of the stile or rail is obtained. The outer edge of the stiles is covered with a ⅞-inch strip of the finish-wood. The core thus made is covered with a veneer of hardwood ¼ of an inch thick. The rails are tenoned into the stiles in the usual way, except that a ½-inch haunch is left the full width of the rail (less the groove for the panel-tongue) which fits into the groove in the stile as shown by the isometric drawing *E*, Fig. 380. The panels are not tongued into the stiles and rails, but a hardwood strip of the thickness of the panels is glued into them instead. Against this strip the panel-moldings are glued, thus leaving the panel loose and free to move. If the panels of solid, pine doors were secured in this way there would be no chance for the panels to crack. When the door contains a single, glass panel a strip should be glued into the stiles and rails as if for a panel, but the inner panel-mold should be cut off flush with the top of the strip and a

ne
To
ne.

Fig. 381. Detail of Moldings when Door is Glazed.

Fig. 382. Veneered Panel in Veneered Door. (See Fig. 377.)

separate molding, wide enough to cover both the strip and the panel-mold, should be tacked in to hold the glass, as shown in Figs. 381 and 383. Some modern processes use thinner veneers.

If the panels are very wide they, also, should be veneered, the

grain of the core running at right-angles to that of the veneer. Fig. 382 shows a section through the stile and panel of the door shown in Fig. 377, and Fig. 383 represents a section on the line *A B*, Fig. 379

Fig. 384 shows a section through a door, made in two halves and glued together, the paneling on the opposite sides of the door being different.

When it is desired to make a door or wainscot appear like one wide board or a number of boards glued together flush with each other, as in the door shown in Figs. 378 and 385, a different method of veneering and building up must be employed. For such a door the frame is glued up in the usual way, and the flush panels are made by gluing together edgewise a number of pieces of pine, ash or chestnut, 3 or 4 inches wide. Care should be taken that the direction of the annual rings in each piece is reversed, as shown at *BB* in the horizontal section, Fig. 385, which shows the construction of the bottom portion of the door shown in Fig. 378. The edges of the strips are also doweled together, as shown in the section.

On the door thus formed are glued four veneers, each about 1/16 of an inch thick, two on each side, in such a way that the grain crosses. The grain of the core and the finish run in parallel directions. The inner or cross-veneer is usually of oak.

Fig. 383. 'Section of "Dutch" Door. (See Fig. 379.

The advantages of doweling, over setting hard-wood strips in grooves the whole length of the edge, were explained in Art. 248.

If the door is to be ornamented by carving below the surface the core must be cut out after it is cross-veneered, and a block of finishing-wood, of the same color and grain as the veneer, set in at the proper place to receive the carving, as shown at *A*, Fig. 385. If the carving is to be above the surface, a piece of the finishing-wood is first sawed to the outline of the carving, glued to the door and then carved.

The above paragraphs and illustrations show the general principles according to which good doors should be detailed and made; but it is impossible for the architect to be sure that they have been

built as specified unless he sees them in process of construction at the shop. The contract for fine, interior woodwork should therefore provide for a strict guarantee of the quality and durability of the work, and even then it is much better, both for the architect and his client, to let the work only to a firm having an established reputation for first-class work.

Fig. 384. Detail of Door with Different Panels on Opposite Sides.

Fig. 386 shows various examples of solid and veneered doors. Sections *i* to *o* show veneered stiles and rails with solid panels, except *k*, which shows veneered panels. Sections *a* to *h* show varieties of common, solid doors; sections *p* to *u* smaller, lighter doors, such as are used for dressers, china-closets, etc. (See, also, Art. 315.) Fig. 387 * shows the construction of the veneered entrance-doors and frames of the Union County Court House, Elizabeth, N. J., designed by Ackerman & Ross. Sections *c* and *d* are vertical sections through the lower and upper portions of the doors; sections *a* and *b* are horizontal sections through the meeting-stiles and jamb, respectively. It will be noted that the exterior and interior faces of the doors are very different. The cores of the rails and stiles are of white pine and their veneering of white oak; the paneling is made up of three thicknesses of white oak. The doors turn in the jamb on heavy pivots. (See, also, Art. 75.)

Fig. 385. Detail of Construction of Door Shown in Fig. 378.

258. PATENTED DOORS. The methods of door-construction thus far described are not protected by patents, and can be adopted by any one having the necessary facilities. There are, however, a few devices for doors that have been patented, and can therefore be used only by the patentees or under license.

* Redrawn and adapted, by permission, from "Building Details," Frank M. Snyder.

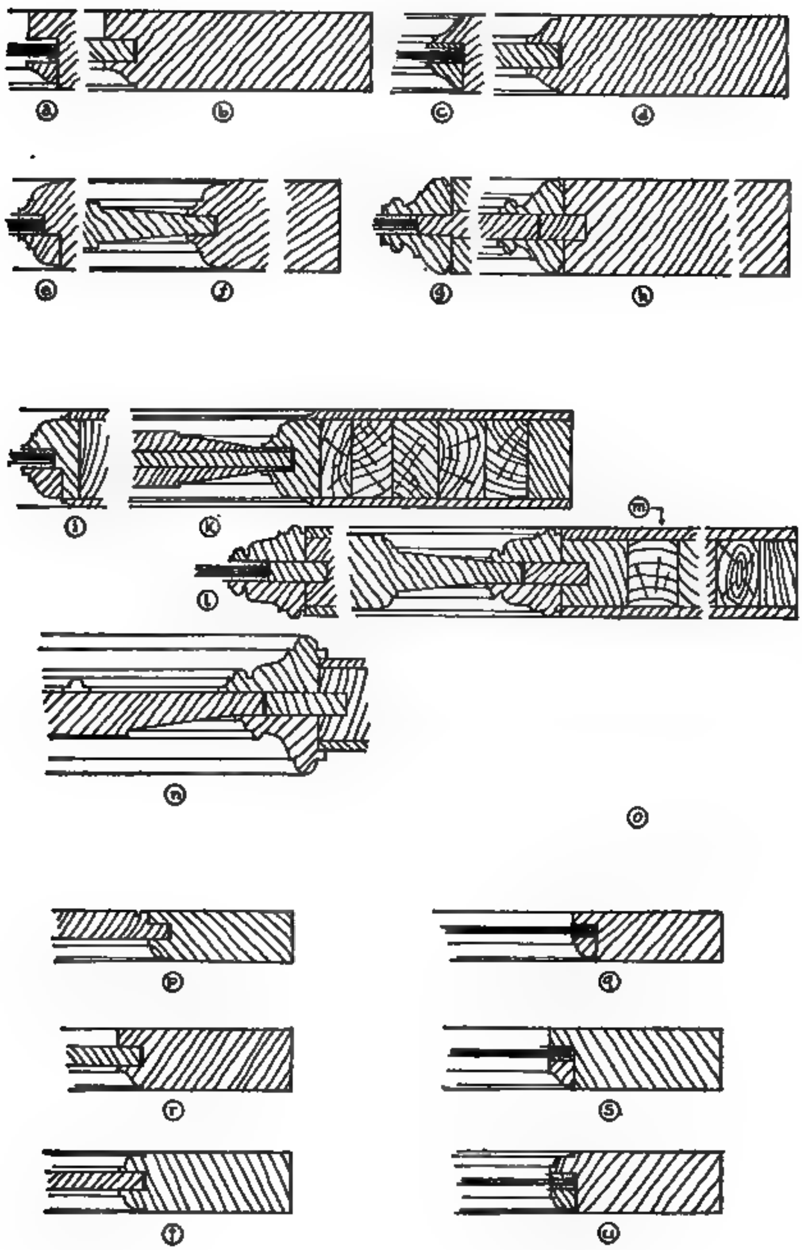


Fig. 386. Solid Doors, Veneered Doors, Doors for China-Closets, Etc.

Fig. 388 shows a section of stile, half full size, of a patent, veneered door.* The patent applies to the manner in which the veneer is laid on. The interlocking of the core and veneer by doubling the gluing-surface prevents the veneer from peeling, warping or checking. This construction is especially desirable for outside, veneered doors.

Fig. 389 shows a cross-section through the stile of the "Kore-lock" patent, veneered door.† The core is made up of pieces dovetailed to each other and to the end pieces. The panel is made up of three thicknesses. The doors are made with stiles and rails of varying widths and with solid, raised or flush panel-molds.

Fig. 390 shows an isometric perspective of the "Sterling Laminated" flush-veneered door.‡ These doors have no panels, but instead, one flush, even surface. In fine woods, like mahogany or Circassian walnut, they are less expensive than paneled doors. There are fewer joints to open or come apart. The drawing shows the face-veneer at *A*, the cross-banding at *B*, the hard-wood bands on both edges and across the top and bottom at *C*, the dovetailed core at *D* and the suggestions for possible inlaying or carving at *E* and *F*. The cores or "center stock" are not only kiln-dried, but subjected to a treatment which removes all acid from the wood. This leaves the fiber sound but lifeless, with the

Fig. 387 Entrance-Doors and Frame. Union County Court House, Elizabeth, N. J.

* Made by the Compound Door Company, St. Joseph, Mich.

† Made by the Paine Lumber Company, Oshkosh, Wis.

‡ Made by the Roddis Lumber and Veneer Company, Chicago, Ill.

warping and twisting qualities destroyed, and in good condition for receiving the laminations of cross-banding and face-veneers.

Fig. 388. Patent Veneered Door. Compound Door Company.

Fig. 389. The "Korelock" Patent Veneered Door.

Fig. 391 shows in isometric perspective a door * of somewhat similar construction to that shown in Fig. 390. The dovetailed cores, however, have splined hard-wood strips on the two sides and two ends. Thus a very

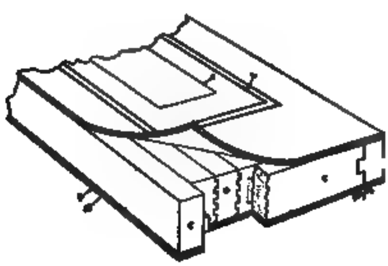


Fig. 390. The Sterling Laminated, Flush-Veneered Door.

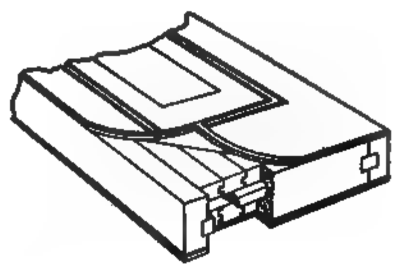


Fig. 391. Flush-Veneered Door.

strong and durable construction is secured. The face-veneers, 1/16 of an inch thick, are laid at right-angles to the veneered cross-banding.

Fig. 392 shows the constructional elevation and a horizontal section of part of the rail, stile and middle part of another patented door.† This is a laminated, compound door, the weight of which, it is claimed, is not much more than half that of a solid door. The doubled stile-piece is interlocked to the tip or edge-piece, and rails and air-spaces alternate with ribs across the door. A lock-block is set in at the proper place for the lock.

* Made by the Hanson-Ward Veneer Company, Bay City, Mich.

† Made by the Carnahan Manufacturing Company, Loogootee, Ind.

Special kinds of doors, such as flexible doors, or rolling partitions (see Art. 278), revolving doors (see Art. 259), etc., are described under these headings. Special methods of hanging doors of several folds for closing wide openings are described in Art. 366, Chapter VI. Fig. 392a shows the "Pyrono" flush-veneered fire-proof and air-proof door.* The "Pyrono" process is a mechanical one for fire-proofing wood cores in the manufacturing of interior trim and furnishings. Partition-doors and frames, wainscots, and ceilings are treated by this process which consists of covering the cores with a fire-proof sheathing of pure asbestos and indenting it into the core at numerous points under heavy pressure. This fire-proof sheathing being in permanent contact with the core excludes the oxygen necessary to combustion, prevents ignition, and at the same time permits, through small openings at the base of the indentations, the escape of the gases developed from the core-wood under high temperatures. The sheathing is treated to prevent moisture from reaching the core and therefore the door will not shrink or swell. The enlarged detail shown in Fig. 392a clearly explains this construction and shows the application of moldings. When other materials than wood are required as finishes, such as metals, compositions, fabrics, etc., they are applied directly over the indented, asbestos sheathing.

Fig. 392. The "Evans-Process" Flush Door.

259. REVOLVING DOORS. The most efficient ventilating-system in any building is seriously handicapped by improper exit-regulations. The difficulty of an adjustment is manifest not only in the cold, disagreeable and unsettled months of the year but also in hot weather, and it has raised serious problems for the architect and the heating and ventilating-engineer to solve. Heretofore, to overcome it, double and triple sets of swinging doors have been provided, or where space is limited, temporary storm-sheds have been put up in the fall and taken down in the spring. All these precautions, however, have been found to be only partially successful and the great necessity for a device for public or semipublic entrances that would be more efficient, led to the invention of the "revolving door," which was first successfully introduced and operated in the year 1888. Its inventor and promoter, Mr. T. Van Kannel, after an exhaustive investigation and severe tests of his discovery, was awarded the highest medal by the Franklin Institute of Philadelphia. Letters patent were taken out by the inventor and all the important patents on revolving doors are now exclusively owned and controlled by the Van Kannell Revolving-Door Company of New York City.

* Manufactured by The Pyrono Process Company, Columbus, Ohio.

At the present time revolving doors are looked upon as being next to indispensable for office-buildings, hotels and other buildings where large numbers of people pass in and out and where it is desirable to meet all kinds of weather-conditions such as wind, snow, rain, dust and cold. They may be seen in operation in all the principal cities in this country and in Canada and also in many European cities.

The "Standard" revolving door consists of a circular vestibule 7 feet in diameter and 7 feet 6 inches in height inside. The front and back of this vestibule are open, as shown in the illustrations, but the top or ceiling and the two circular walls form a complete enclosure. The revolving portion of the structure consists usually of four wings, although there are three and six-wing cases, which are joined at the center and pivoted at the top and bottom. The upper pivot or shaft is suspended from a self-adjusting carriage-bearing placed on a four-wheel track arranged in two strong iron channels placed in the ceiling-chamber. The wings are joined together in the center in such a way that they may be folded flat on each other instantly and moved to one side in a short period of time.

Fig. 392a. "Pyrono" Flush-Veneered Door.

Each set of revolving wings should be equipped with a governing device attached to the central shaft to control the speed of the wings when revolving and to prevent their spinning if pushed violently. This device, which is patterned after a "liquid" door-check, does not in any way interfere with the regular rotation of the wings, but simply avoids the possibility of accident due to the rapid spinning of the door. This governor can be regulated to any degree of pressure required and will check the speed of the wings in one revolution.

If it is necessary that the wings revolve continuously for some time, as is often the case in department-stores, hotels, etc., they may be equipped with an electric motor-control device which is placed above the ceiling of the door and attached to the central shaft. This device may be run continuously, or started and stopped at will, and regulated up to a speed of 200 revolutions per minute.

The outer edge of each wing has a molded rubber weather-stripping, which projects about 2 inches. This allows the revolving

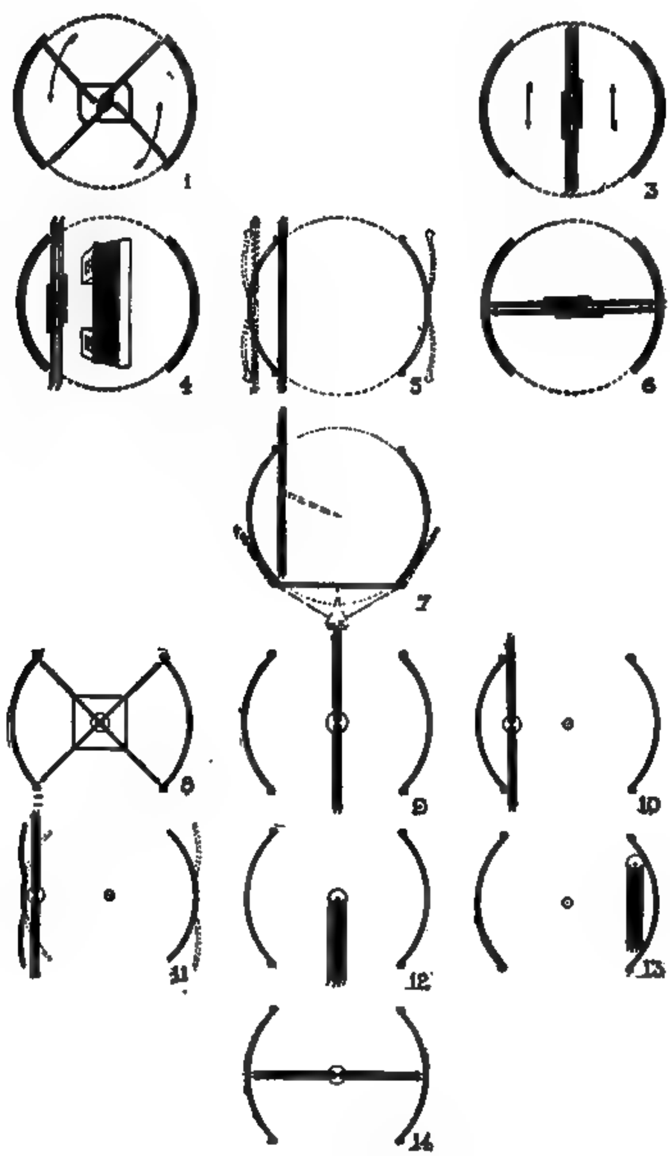


Fig. 393. Operation-Diagrams of Standard and Collapsible Revolving Doors.

wings to fit the side walls snugly and is what is termed the "air-locking device." Together with the top felt packing and bottom flexible-rubber packing, it makes a complete air-locked door, no matter what position the wings assume, since the four wings touch on the sides of the vestibule when placed at either quarter-line.

The operation of the door is indicated by the fourteen diagrams shown in Fig. 393. The first seven diagrams show the standard revolving doors and the last seven the automatic collapsible, panic-proof revolving doors.

The first seven diagrams (Fig. 393) show the following positions: Diagram 1 is the revolving-position, with the four wings extended, permitting persons to pass in and out but at the same time excluding wind, snow, dust and noise, to all of which, indeed, the entrance is always closed. Diagram 2 is the half-open position, with one wing folded back so that long objects may be passed through. A wing may be opened as quickly as an ordinary hinged door, and the hinged drop-arm holds the folded wing back automatically. Diagram 3 is the central-open position, with two hinged wings folded flat on the two permanent wings and bolted to the ceiling; this gives two half-width passages for the separation of ingoing and outgoing passengers. Diagram 4 is the full-open position, in which the wings are folded and moved aside for the passage of bulky furniture, pianos, etc., for processions and for full ventilation. There is no obstruction to the view. The wings may be folded and moved aside by one person in ten seconds. Diagram 5 is the full-open position. The condition which is the same as in Diagram 4, shows the practical use of flexible, hinged walls. This method gives the greatest width for the full-open vestibule. Diagram 6 is the locked position, in which the four wings may be folded, placed transversely across the circular vestibule, and securely locked or bolted. Other locking-methods are adopted in special cases. Diagram 7 is the special full-open position. The wings are folded and moved aside, in order to permit the use of a swinging fly-door in summer, or whenever it may be desired.

The revolving wings of the panic-proof doors are hung independently of each other on a central shaft. They are held in a radial position by means of flexible, bronze cables and are so arranged that by the application of unusual pressure to any part or parts of any two of the revolving wings, the wings automatically collapse and fold flat on each other in an outward position. The seven diagrams following show the collapsible, panic-proof revolving doors:

Diagram 8 shows the revolving position, the four wings being extended as in 1. Diagram 9 is the central-open position in which the wings are folded flat in pairs and locked in position, giving two half-width passages, to separate traffic. Diagram 10 is the full-open position in which the wings are folded and moved aside, for handling bulky objects. Diagram 11 is the full-open position with the wings folded and moved aside, and with the hinged walls flexed for added space. Diagram 12 is the panic, collapsed position, in which the wings are folded on each other in the outward position, as the result of panic or for other reasons. Where flexed walls are used, as in Diagram 11, in case of panic the walls flex automatically outward as the wings take their collapsed position. Diagram 13 is the full-open

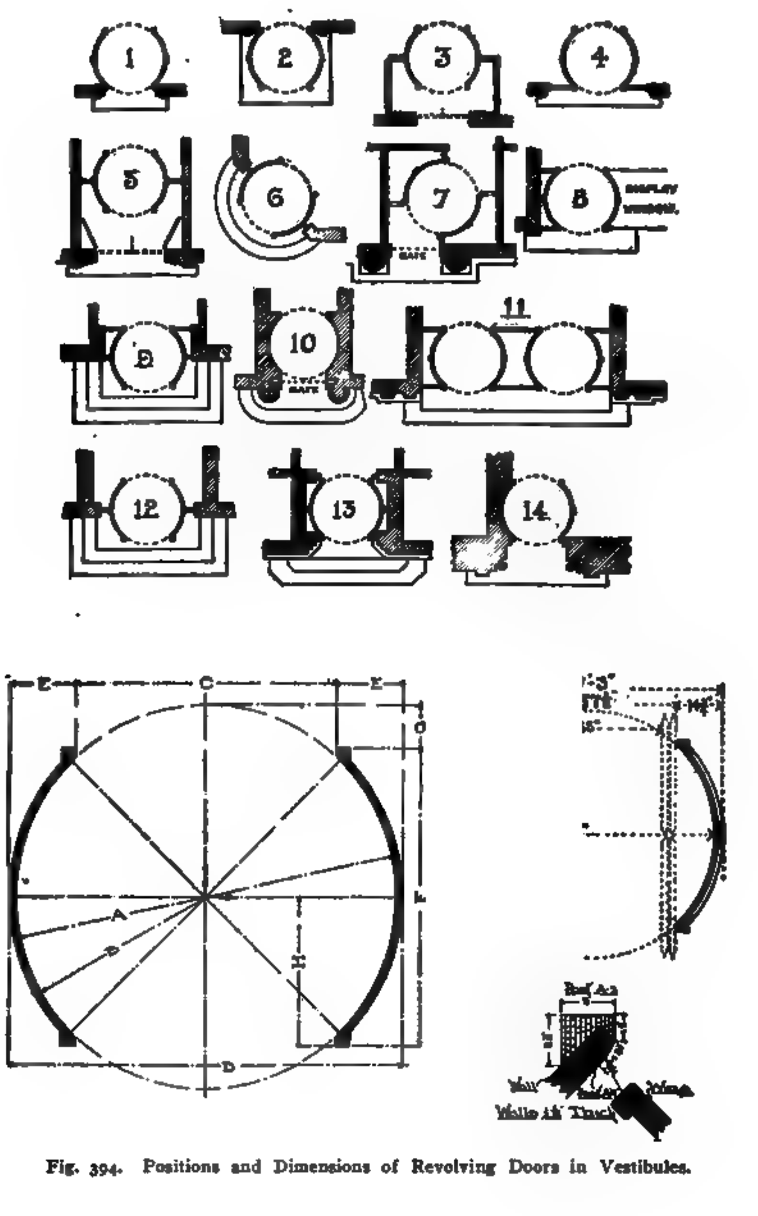


Fig. 394. Positions and Dimensions of Revolving Doors in Vestibules.

position in which the wings are folded on each other and moved to one side. Diagram 14 is the locked position. Four wings are folded in pairs, placed across vestibule, securely locked. The lock is operated from both sides.

Fig. 394 shows various positions of revolving doors in vestibules, as follows: 1. Placed inside the doorway; 2, placed outside, resting on a platform; this requires a roof over the structure; 3, joined to the jambs of an interior vestibule, with hinged doors in front for closing at night; 4, a wide entrance, space filled in by two glazed panels; 5, revolving door set back in a hallway, old swing doors left in place; 6, a corner entrance, center pilaster of curved walls joined to building-jambs; 7, diagonal entrance, the revolving door making an excellent approach both inside and outside; 8, store-entrance, with display-window, the curved wall of the revolving door forming the glazed sash for display-window and the other curved wall made solid when placed near wall of building; 9, half of revolving door inside the solid wall-sections, other half outside, having glazed walls and requiring roof outside of transom; 10, "permanent-wall" revolving door, collapsible gates in pockets; 11, twin, revolving doors, at an entrance about 18 feet wide, which allows for a central display-case, an entrance of 15 feet being sufficient for two standard doors; cornice, inside and outside, straight from wall to wall of the building; 12, like 9, except that both walls are glazed; 13, jambs of revolving door joined directly to the four jambs of the building; 14, showing building-wall cut out to permit curved wall of revolving door when put in place, to make a correct junction at front entrance.

The large diagram of Fig. 394 shows the eight distances in plan for which dimensions are required for four-winged revolving doors, while the diagrams to the right of this show, above, the dimensions in plan for the average and most commonly used revolving door; and, below, the detail of wall and post and of wing of door with space between, which is covered with molded-rubber stripping tipped with heavy felt.

260. INSIDE-DOOR FRAMES. 1. *Different Types of Construction.* The construction of inside-door frames varies in different parts of the country. In New England and in some of the middle states the frames are usually made of 1¾-inch plank, rebated ½ an inch for the door, and, in the better class of work, beaded on the edge, as shown at *D*, Fig. 395. The side pieces or jambs are "housed" or let into the head and nailed from the top. In some if not all of the western states the frame is made of plain ⅞ or 1⅛-inch boards housed together, and with a "stop" nailed or screwed to the frame for the door to strike against, as shown at *E*. The former method is probably the best for heavy doors, as it gives more depth of wood for the screws; but in wood partitions a frame such as is shown at *E*, if 1⅛ inches thick, can be made perfectly solid and will hold any ordinary door. Besides being the cheaper frame it has an advantage in that the door can be changed to swing on the other side of the partition by reversing the stop-bead; moreover the head of the frame is at the same level

on both sides of the partition. In a frame such as is shown at *D* the "casing" or the "trim," owing to the rebate, will be ½ an inch higher on one side of the partition than on the other, so that if two doors come near together and swing on different sides of the

Fig. 395. Details of Inside-Door Frames.

partition the difference in the height of the head-casings will be very noticeable; on this account such a trim is undesirable. This defect may be overcome, however, by rebating both edges of the frame.

In setting the studding the rough opening should be of such a width that there will be about ¾ or ⅞ of an inch between the back of the frame and the studs to allow of plumbing the frame. Wedges are then driven back of the frame and the frame nailed to the studs. In cabinet-work the frame should be 1¾ inches thick to permit nailing behind the casings.

The width of the frame should be just equal to the distance between the faces of the grounds, which should be set perfectly plumb. The grounds should also always be kept a little back from the edge of the studs, so that they will not be disturbed in driving the wedges back of the frame.

2. *Hardwood Frames.* The sections shown at *D* and *E*, Fig. 395, are for frames of softwood. If the finish is to be of hardwood the frames should be veneered as shown in sections *G* and *H*, with veneering ½ an inch thick. If the rooms connected by the doorway are finished in different woods the same woods should be used on the frame, in such a way that when the door is shut the frame will appear to be of the same wood as the finish of the room. If the corner of the frame is to be beaded it will be necessary to veneer the edge of the frame also.

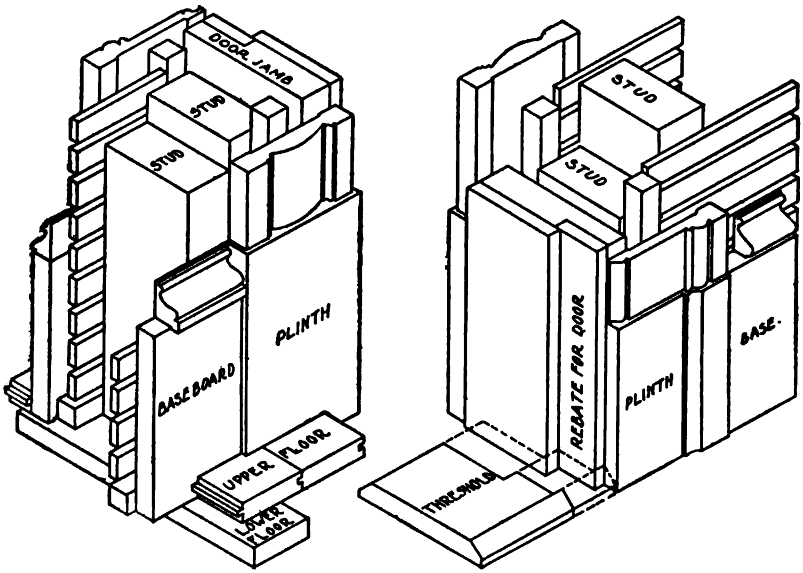


Fig. 396. Isometric Perspectives of Inside-Door Frames and Trims.

When the frame is made with the stop-bead planted on, the entire frame is often made of hardwood, especially of the lower-priced

woods; but the veneered frame will stand better. When adjoining rooms are finished in different woods veneering is necessary.

3. *Paneled Jambs.* When the partitions are 10 inches or more in thickness, as they will be if built of brick, the door-frames should be built up, either in the form of panels, as shown at *I* (called "paneled jambs"), or in two parts, as shown at *K;* the latter is obviously the cheaper method, but does not look quite as well. If the finish is to be of hardwood the frame should be veneered and the panels and moldings should be of hardwood. In churches and public buildings a narrow frame is often set on one side of the partition, as in *K,* the rest of the jamb is then plastered and a small molding placed in the angle made by the frame and plaster. (See Art. 163, Chapter III.)

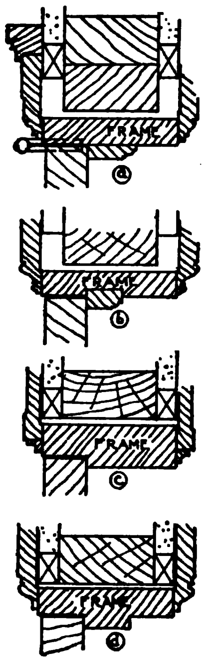


Fig. 397. Details of Inside-Door Frames.

Fig. 398 shows a detail of an interior, door-trim paneling, stop, etc., for a door-frame with a wide jamb. Fig. 396 shows two isometric perspectives of interior door-frames and trim used with stud-partitions. These two illustrations show very clearly the relations between the different parts and the general construction. Fig. 397 shows some additional details of interior door-frames in stud-partitions, *a* with the stop planted on, *b* with the stop ploughed in, *c* with a single rebate and *d* with a double rebate.

4. *Frames for Double-Action Doors.* For double-action doors the frames should be made of a plain board or plank with a hanging-strip let into the hanging-jamb of the same thickness as the door, as shown in Fig. 399. The other jamb and the head are usually left plain, unless there are double doors, in which case, of course, both jambs are treated alike.

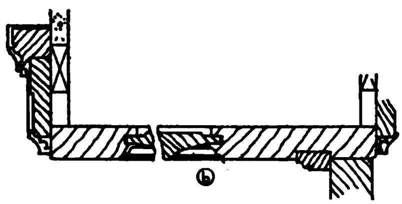


Fig. 398. Paneled Door-Jamb for Thick Wall.

5. *Frames for Sliding Doors.* These are usually made of plain ⅞-inch boards with a molded strip, similar to a "stop," bradded on each side of the pocket, as shown in Fig. 400.

6. *Miscellaneous Examples of Door-Frames.* Fig. 401 * shows sections through the jambs of the door-frames and vertical section

Fig. 399. Frame for Double-Action Door. Fig. 400. Frame for Sliding Door.

through the lower part of the doors of the Public Library, at Port Jervis, N. Y., designed by Ackerman & Ross. The frame at *a* is in a stud-partition, and that at *d* is used in brick walls.

Fig. 402 * shows horizontal sections through the interior doors and door-jambs of the Carnegie Library Building, Atlanta, Ga., designed by Ackerman & Ross. The doors are all veneered with white oak on white-pine cores. All the sections show the frames and trim for 17-inch brick walls, except section *g*, which is for a 4-inch tile partition. At *a* is a plaster jamb, door swinging out; at *c*, a wood trim with paneled jamb, door swinging in; at *d* a Keene's-cement trim, paneled in the jamb, with double-swing door and leather-covered door-stiles; at *e* a wood trim, with paneled jamb, door swinging out; at *f*, a horizontal section at glazed door-panel; at *h* a flush-paneled door, with the door and trim painted the same as the wall on the flush side and with the marble base continued across and screwed to the bottom of the door; and at *g* a wood trim, frame and door-stile in a 4-inch tile partition with 3 by 4-inch wood buck.

Figs. 403 * and 404 * show sections through double doors and door-frame between bedrooms and bath-rooms in the residence of Mr. George D. Wick, Youngstown, Ohio, designed by Charles Barton Keen. The double doors, with air-space between, are for the purpose of deadening the sound. The doors are of white pine, solid, $1\frac{5}{8}$ inches thick on the bedroom side and $1\frac{3}{8}$ inches

* Redrawn and adapted, by permission, from "Building Details," Frank M. Snyder.

thick on the bath-room side. The bedroom doors are glazed with plate-glass mirrors as shown. The construction of the frames, which are in 2-inch metal-lath-and-angle partitions, is clearly indicated.

261. FINISH AROUND DOOR-OPENINGS. 1. *Different Names for the Finish.* The finish on each side of a door-opening and also about the window-openings is variously designated by the terms "trim," "casing" or "architrave." The term "casing" appears to be the most widely used, and has been adopted by the author. The term "architrave" is frequently used to designate the piece inside of the "back-band."

Fig. 401. Doors and Door-Frames. Public Library Building, Port Jervis, N. Y.

2. *Block-Finish or Pilaster-Finish.* Various methods of finishing the door-openings are also employed. The style of finish shown at *A*, Fig. 395, is termed "block-finish" or "pilaster-finish"; square blocks are placed in the upper corners and the casings butt against them. The blocks are usually ornamented by turned rosettes or by carving. In this style of finish any shrinkage in the casings does not show, as they will not shrink lengthwise; and, since the block is made ⅛ of an inch thicker than the casings, any shrinkage in the block will be hardly perceptible. The blocks are also generally made ¼ of an inch wider than the casings.

3. *Mitered Finish.* The style of finish shown at *B*, Fig. 395, is known as "mitered finish." When mitered finish is used, especially if it is to be varnished, it is absolutely necessary that the wood be thoroughly dry, as any shrinkage in the casings will cause the mitered

Fig. 402. Door-Frames. Carnegie Library Building, Atlanta, Ga.

joints to open very perceptibly. In painted work this can be remedied by putty and another coat of paint, but in varnished work the crack cannot be hidden.

·SECTION·THRO·SIDE·OF·BATH·ROOM·DOORS·

Fig. 403. Horizontal Section of Doubled Doors in Two-Inch Metal-Lath-and-Angle Partition.

4. *Casings of Several Members.* The casings may be composed of one or more members as desired, but if they are to be more than $^{13}/_{16}$ of an inch thick it is better to make them of two or even more members, as shown at *E* and *F*, Fig. 395. If two pieces are used there is less danger of shrinkage and less stock required.

5. *Back-Bands.* In Section E, Fig. 395, the piece *b* is called the "back-band," and is rebated so as to fit over the casing or "architrave" about ⅝ of an inch. In varnished work the trim should be built up in this way rather than by simply planting a thin molding over the casing, as it shows no joint at the back of the casing, and the rebated joint between the two members, while allowing for slight shrinkage, keeps it invisible.

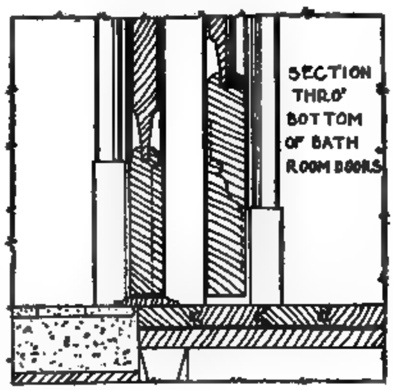


Fig. 404. Vertical Section Through Bottom of Doors Shown in Fig. 403.

6. *Block-and-Miter Finish.* At *C*, Fig. 395, is shown a combination of the block-and-miter finish, which is very suitable for ordinary hardwood work. A section of the finish is shown at F. The casing is made ⅝ of an inch thick by from 4 to 4½ inches wide, and has blocks in the upper corners of the same thickness as the casing. The back-band extends around the block and is mitered at the corner. This does away with the mitered joint in the casing and does not look as heavy as the block-finish.

7. *"Straight-Joint" Casing with Mitered Moldings.* Fig. 405 shows another method of constructing a door or window-trim. In this case a flat molding is planted or glued on the casing and

another molding glued to the outer edge to cover the joint. At the corner the molded portion of the casing is mitered, but the plain part has a straight joint as shown at *a*. With the same amount of shrinkage, such a joint will open less than a mitered joint.

In putting up the finish the architrave or casing should be kept about ¼ of an inch back from the edge of the frame, as shown in the sections.

8. *Casing-Sections and Caps.* The design or profile of the door or window-finish may be varied to an almost infinite degree. These drawings have attempted not to suggest moldings, but merely to show the general methods of using them. Pilaster-casings with corner-blocks should as a rule have both edges alike. In Fig. 406 a few sections of casings that have been used by various architects are given as a suggestion to the draughtsman. A few designs for cornices or "caps" above the doors and windows are also given. At *A* is shown a simple cap, worked from a single ⅞-inch board, which makes a neat and inexpensive finish. When the picture-molding comes just above the top of the door or window-casing, it will look much neater if the head-casing is made wider than the others, so that the picture-molding may break over it, as at *C*.

Fig. 405. Detail of Door or Window-Trim.

9. *Pilaster-Casings and Cornices.* Fig. 407 shows three different arrangements of pilaster-casings with cornices. The detail at *B* is from colonial work. The detail at *C* makes a neat and not very expensive finish, and one that has no mitered joints. The egg-and-dart moldings may be machine-work.

10. *Pilaster-Treatment.* Fig. 408 shows still another design for a pilaster-treatment, after the German style. For very elaborate finish, especially in public buildings, the pilasters are often terminated by inverted consoles which support the cornice.

11. *Heavy Casings, Pilasters and Cornices.* In Fig. 409 is shown a mitered casing with the back-band broken at the top, an arrangement quite frequently seen. Fig. 410 shows a heavy pilaster-finish with a highly ornamented cornice. These last two examples are from colonial mansions.

When a heavy pilaster is placed on each side of a door or window-opening it is generally better to set the pilaster 3 or 4 inches back

from the edge of the jamb, with a narrow architrave around the opening, as in Fig. 410.

12. *Openings of Different Heights.* When door and window-

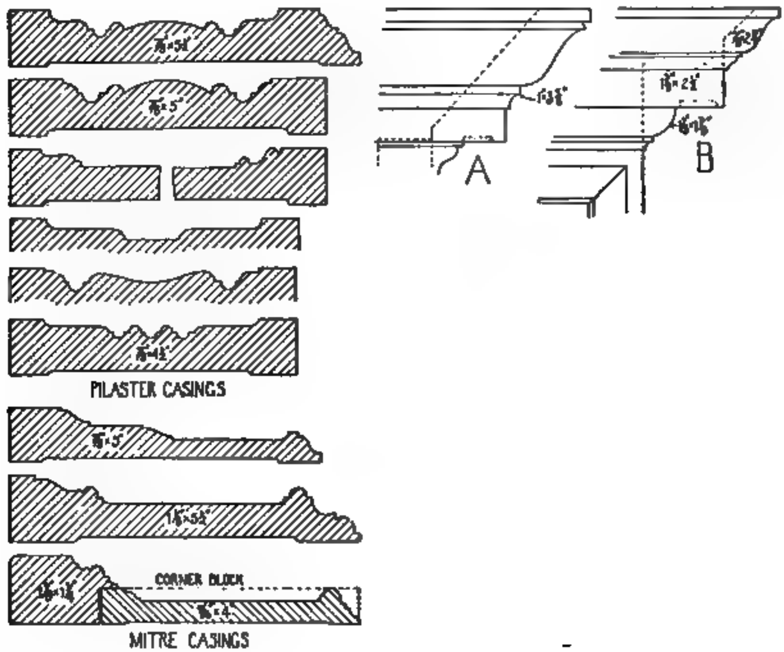


Fig. 406. Casings and Cornices for Doors and Windows.

openings are finished with cornices the appearance of the room and of the wall-decoration will be enhanced if the cornices are on the same level above all of the openings; as the window-heads are usually higher above the floor than the door-heads, a little different arrangement of the finish is required to bring the cornices to the same level.

Fig. 411 shows a very simple arrangement that the author has used with good effect, for overcoming this difficulty. If the difference in the height of the doors and windows is more than 9 inches, however, it will be necessary either to place a transom or an ornamental panel over the doors, or else let the cornices be at different levels.

13. *Joining Door and Wainscot-Finish.* When the room is wainscoted the draughtsman should not forget to consider how the cap and base are to stop against the door-finish. Usually the trim

is finished with a wide back-band, as in Figs. 400 and 483, but where the cap of the wainscoting is quite heavy, as is often the case in

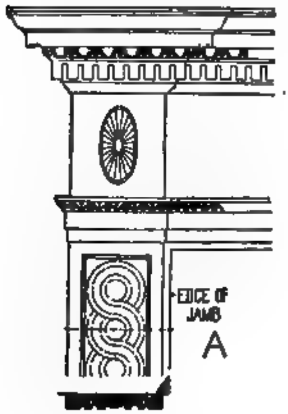


Fig. 407. Cornices and Pilaster-Casings.

public buildings, it is necessary to place a narrow pilaster or bracket just beside the door-trim in order to stop the moldings of the wainscot, as shown in Fig. 501.

14. *Plinth-Blocks.* When the door-casing is less than ⅞ of an inch thick the base does not finish well against it, and a "plinth-block" should be placed at the bottom of the casing, as shown at *A*, Fig. 395, and also in Fig. 480. This block should be about ¼ of an inch higher than the base, and at least ⅛ of an inch thicker than the base or casing. With pilaster-casings the plinth usually has a plain rectangular section, but with mitered casings the plinth has a section corresponding in outline with that of the casing, as shown at *P*, detail *F*, Fig. 395, and also in Fig. 399. With 1⅛-inch casings or back-bands, and a ⅞-inch base, plinths are not necessary and are often omitted, even in the best work, according to the taste of the architect. Aside from stopping the base, however, the use of a plinth-block prevents the more delicate moldings of the casing coming into contact with the floor, where they are apt to become filled with dirt.

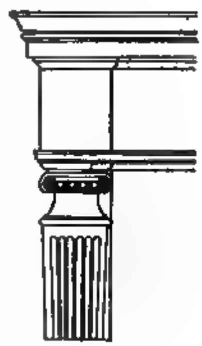


Fig. 408. Pilaster-Casing. German Type.

Fig. 409. Mitered Casing. Colonial Type.

Fig. 410. Heavy Pilaster and Cornice-Casing. Colonial Type.

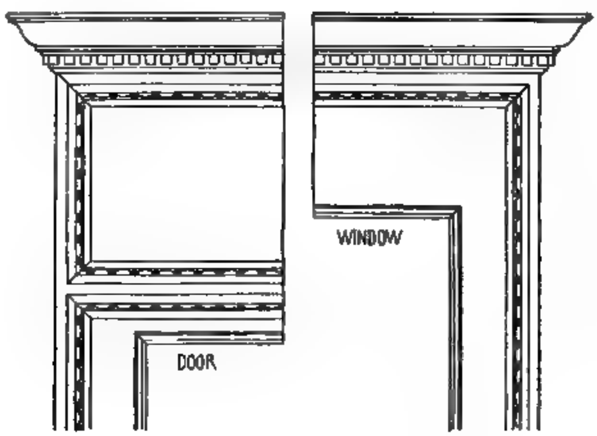


Fig. 411. Equalized Heights of Door and Window-Trims.

4. FINISH AROUND WINDOWS.

262. WINDOW-CASINGS, JAMBS, SILLS, ETC. The same trim or casing is always used around the windows as around the doors, and when the box-casing or ground-casing, or, in the absence of these, the edge of the pulley-stile, is flush with the

pilaster, the finishing of the windows is exactly the same as that of the doors, except that the window-trim usually stops on a "stool." The stool is made most frequently of the shape shown in Figs. 153, 154 and 163, and is rebated to set over the wood sill. In the better class of work it is usually 1⅛ inches thick, and should be wide enough for the casings to stop against. Many architects prefer to tongue the stool into the back of the sill about ½ an inch below the top of the latter, as shown in Figs. 155, 164 and 181. When this is done the stop-bead is carried across the top of the stool as shown. When jamb-casings are required (see Art. 141) the latter method makes perhaps the neatest finish, but in thin walls where there are no jamb-casings the author prefers the former method, as it gives a wider stool. Under the stool a molding or board called the "apron" is always placed to cover the "ground" and the rough edge of the plaster, and also to help support the "stool." The apron should be at least 3½ inches wide.

When the box casing (see Art. 141) does not come flush with the plaster, jamb-casings, sometimes called "linings" or "sub-jambs," are necessary to make a finish between the architrave and the frame, as shown in section in Figs. 164, 165, 181 and 182. The jamb-casings are usually made of plain boards and the inner edge is generally just flush with the plaster. If a deeper recess is desired, the architrave may be set against the back of the jamb-casing, as shown at *A*, Fig. 412, but this requires additional grounds, and is not so good a method as the more common one shown in Fig. 164. In a thin wall the stop-beads may be brought flush with the casings when greater width is required, as at *B*. If the width of the jamb-casing exceeds 6 or 7 inches it will have a better ap-

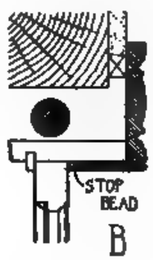


Fig. 412. Jamb-Casings. Fig. 413. Splayed Jamb-Casing.

pearance and stand better if paneled. Very often the jamb-casings are splayed, as shown in Fig. 414, a colonial example, and occasionally they are molded across their full width, as shown in Fig.

413. This finish is especially appropriate to deep, mullioned windows.

263. PANEL-BACKS UNDER WINDOWS. In thick walls, whether solid, or furred for shutters, the portion of wall between the window-sill and the floor is often made of less thickness so as to form a recess. The back of this recess is then generally paneled between the jamb-casings, although it may be plastered and finished with a base and apron. Windows recessed in this way are said to have "panel-backs." With panel-backs the architraves and jamb-casings are carried to the floor and finished like those around the doors. Two very simple panel-backs are shown in Fig. 415. Fig. 414 shows a section and partial elevation of a window with panel-back, paneled jambs and inside shutters. The jambs, box casings and stop-beads and other parts of the frame-finish that show, should always be of the same wood as the architrave or casing.

Fig. 414. Splayed Jamb-Casings. Colonial Type.

5. PUTTING ON THE INTERIOR FINISH.

264. DIFFERENT METHODS OF PUTTING ON INTERIOR FINISH. The manner in which inside finish is put on or fixed in place varies with the quality of work desired, and greatly affects the appearance of the finish, particularly when this is in its natural color. In painted work and in ordinary joiners' work the different parts of the finish are nailed to the wall or grounds and to the edge of the frames with finish-nails, which are sunk beneath the surface of the wood for puttying. To conceal the nail-holes as much as possible, for they cannot be entirely concealed by the putty even when the finish is painted, the nails should be driven in the quirks of the moldings wherever practicable.

Hardwood finish, if nailed, should be bored for the nails in order to prevent splitting of the wood.

In common work the contractor usually has the finish stuck in pieces of random lengths, 12 or 16 feet, and for the sake of economy is sometimes tempted to "splice" the architraves or casings with short pieces. The appearance of a spliced casing, however, is so bad that it is not considered admissible in good work. To provide against it the specifications should provide that "no splicing of the architraves or casings will be allowed."

Fig. 415. Panel-Backs Under Window.

Nail-holes in hardwood, even when puttied in the most skillful manner, greatly mar the appearance of the finish, so that in the best grades of work it is generally required that all the members of the door and window-trim shall be glued together on the bench and put up with as few nails as possible.

Very frequently the finish is painted on the back and filled, varnished and rubbed before it is fixed in place. This not only hastens the completion of the building, but because of the painting on the back makes the finish "stand" better. Then, too, by having the work finished at the factory, the wood can be kept perfectly dry and in a room that is free from dust while the varnishers, as soon as the woodworker has finished his part, are putting on the first coat of shellac. In this class of work the side and head-casings are joined together before they are put up.

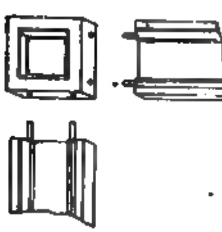


Fig. 416. Doweled Casings and Corner-Block.

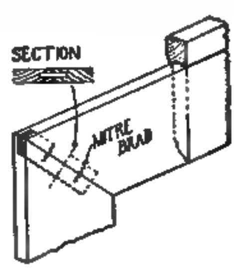


Fig. 417. Casings Mitered and Splined. Back-Band.

Where block or pilaster-finish is used the corner-blocks and plinths are secured to the casings by means of dowels, as shown in Fig. 416, and glue.

Mitered joints are always glued together, and should also have some additional fastening, such as dowels or "splines." When the trim is composed of architrave and back-band, the best construction for the joint is probably that shown in Fig. 417. This is also quite a common joint in the best eastern work. After the pieces are mitered the edges forming the joint are grooved and a hardwood strip or spline is inserted. The joint is then glued and driven together and two steel miter-brads are driven in from the back, making a very solid joint. When the trim is in one piece the spline should not extend to the outer edge, as it would injure the appearance. Ordinary dowels may also be used in a mitered joint, but they are not as satisfactory as the spline.

In the very best work no nails are used, either in joining the pieces or in setting up the work. The finish in such work is attached to the grounds by means of screws placed back of some loose molding or below the finished floor. In this class of work also no large pieces of solid wood are used; the work is made of several pieces glued up, to prevent warping or splitting. There are several establishments in this country that will in this way make all the woodwork for the interior of a building in any portion of the globe, ship it ready finished to the building and send men to put it up. The latter work requires but a very short time. Such work is necessarily expensive, but it is sure to stand well and give satisfaction, and should always be specified when the best work is desired.

6. METAL DOORS, SASHES, FRAMES AND TRIM.

265. METAL DOORS, SASHES, FRAMES AND TRIM. The effort to make the interior or buildings fire-proof has resulted in metal-covered wood and doors, sashes, frames, trim and moldings of hollow steel or other metal. Such finish is now so frequently used that the details of it should be briefly described in a book on carpenters' work, even though the materials are entirely or almost entirely metal rather than wood, the more especially so since it is put in place by methods similar to those employed by carpenters in installing ordinary wood fittings and trim. In fact architects and the manufacturers of such metal finish declare that carpenters are the mechanics most competent to set it properly; and the fact that manufacturers pay carpenters about fifty cents a day more than they would have to pay sheet-metal workers, is sufficient proof that their declaration is honest.

Although many very large buildings have in recent years been equipped wholly or in part with these products, and although the

products themselves have reached a stage of great perfection of workmanship and efficiency, the industry is still really in its infancy. The building-conditions existing in New York City are probably doing more to help its development than any other causes.

At the present time (1912), there are three cities in the United States, New York, Denver and San Francisco, that compel the use of these products for certain parts of buildings which are over a certain height; and it is probably only a question of time when other cities will pass ordinances compelling their use. At the present time cost enters largely into the question of substituting them for wood. In New York City on account of old ordinances compelling the use of fire-proofed wood for the interior finish of buildings over a stipulated height the manufacturers are almost able to meet hardwood figures in competition; but in Chicago, on the other hand, where the use of fire-proofed woods is not compulsory, and where the difference between the cost of wood trim and metal trim is about 30 per cent, nothing short of an ordinance compelling the use of the latter will make that city a good field for the efforts of those who wish to widely extend its use.

The clause in the Building Code of the City of New York, in the section on "Fire-proof Buildings" which relates to this subject, is as follows: "When the height of a fire-proof building exceeds twelve stories, or more than one hundred and fifty feet, all outside window-frames and sashes shall be of metal, or of wood covered with metal, the inside window-frames and sashes, doors, trim and other interior finish may be of wood covered with metal or of wood treated by some process approved by the Board of Buildings to render the same fire-proof."

Among the first attempts in the United States to fire-proof the interior trim of buildings were those made in New York City, about the year 1880, in the form of metal-covered woodwork, by the firm of Campbell & Bantossell of that city. About this time, also, there were introduced along with various processes of fire-proofing woodwork, "fire-proof paints." Later "fire-proof wood" was introduced, that is, wood which has the resin and other inflammable components extracted from it, and the fiber left. In the course of a few years the metal-covered-wood industry developed to such a stage that it was possible to trim with its products the interior of a building and keep a good appearance. Notable examples are the Manhattan Life Insurance Company's building and the Barclay building and, of more recent date, the Metropolitan Tower,* the Fifth Avenue office-building, the Germania Life In-

* The Metropolitan Tower has a metal-covered trim which is a special bronze-plate construction over a wood core. This was developed by The John W. Rapp Company

surance Company's building and the Vanderbilt Hotel, all in New York City; the Hoge building, Seattle, Wash.; the Hall of Records, Los Angeles, Cal.; the Rockefeller Annex, Cleveland, Ohio, etc.

The rough, unfinished appearance of the standard tin-clad door set men to seeking a product for use in interior finish which would lend itself to more decorative effects. The "Kalamein iron" and other metal-covered work resulted. In the meantime improvements were constantly being made in hollow sheet-metal doors and trim and from about the year 1903 hollow-steel construction for this work came into use. Owing to its generally superior workmanship and to the splendid enamel surfaces which can be given it by various baking-processes, this type of interior finish has found favor in the eyes of the architects and owners of modern office, mercantile and public buildings.

266. KALAMEIN (OR KALAMINE OR CALAMINE) IRON AND OTHER METAL-COVERED DOORS, SASHES AND TRIM.* "Kalamein Iron" is the trade name given to one of the open-hearth sheet-steel products which is covered with a thin alloy of tin and lead in much the same way that galvanized iron by galvanic immersion is coated with zinc. "The name Calamine (with Galmei of the Germans) is commonly supposed to be a corruption of Cadmia. Agricola says it is from Calamus, a reed, in allusion to the slender forms (stalactic) common in the Cadmia formation." †

The term "Kalamein" is often used incorrectly, by architects and others, for any form of metal-covered woodwork, whether the metal is steel, copper or bronze, to distinguish metal-covered from hollow-metal construction; but the term is obviously misleading and causes much confusion. In several instances architects have specified "Kalamein material" expecting "bronze metal" to be used in the covering, whereas the manufacturer's interpretation of the specification was that "Kalamein iron" was intended.

267. METAL-COVERED DOORS, FRAMES AND TRIM. The cores of metal-covered doors and frames are built up of oak or white-pine strips dovetailed together lengthwise to the grain. In gluing up the strips into stiles and rails the grain of each strip is reversed in order to resist the tendency of the core to twist. The stiles and rails are mortised, tenoned and box-wedged and the

recently consolidated with The J. F. Blanchard Company into the United States Metal Products Company, New York City.

* Among the better known manufacturers of metal-covered work, whose doors are inspected and labeled by the Underwriters' Laboratories, Inc., are the United States Metal Products Company, New York City and the Thorp Fireproof Door Company, Minneapolis, Minn.

† Dana's Dictionary of Mineralogy.

cores are covered with asbestos paper or board and enclosed with sheet metal (either steel, which may be painted to match a wood trim, or electroplated with copper, brass or bronze) or solid, sheet copper, brass or bronze. For doors up to 3 feet 4 inches in width and 8 feet in height, both sides are often made of continuous sheets of metal, which have the panels pressed into them by hydraulic pressure, and are without seam or joint. The metal sheets of the two sides, in one make of door,* are made to overlap in a depression on the edges of the door and are secured in place by screws which pass through both face-sheets. The standard thickness of this door is 2⅞ inches. When these doors are more than 3 feet 4 inches in width, each face is generally made of two sheets which meet over a middle stile and lock together with a flush double-lock joint. This makes a double row of vertical panels.

The bronze-covered doors † of another make are constructed as follows: The metal covering of the stiles is No. 20, Stubbs gauge, bronze, drawn through a forming-die and applied securely with the edges locked on the inner edge of the stile. Bronze plates, of No. 16 Stubbs gauge, are used for covering the rails and invisible butt-joints are brazed directly to a plate of bronze under the joints. The panels are built up of two sheets of No. 16, Stubbs gauge, bronze, with compressed, asbestos boards between, which are thoroughly cemented together with water-proof cement in a hydraulic press. The moldings, according to their character, are either made of hollow bronze or drawn over oak cores. For hollow moldings, No. 20 and for drawn moldings, No. 22, Stubbs gauge bronze, is used. For this make of bronze-covered doors the trim is usually cold-rolled to the correct profile, from No. 20, Stubbs gauge, bronze. It has no cores, is provided with brazed miters and is secured in place with oval-head screws. The finish may be natural bronze or any oxidized shade desired. Kalamein-iron-covered doors are constructed in the same way, except that No. 26, United States standard gauge, iron is used. Metal-covered doors are also made to receive panels of plate-glass, decorative glass or wire-glass and there are many buildings in which the corridor-windows, doors and trim throughout are made of metal-covered work, glazed in this way. When the hardware is furnished it is fitted at the factories without extra charge. The trim may be metal-covered the same as the doors and frames.

268. METAL-COVERED WINDOW-FRAMES AND SASHES. Window-frames and sashes as well as door-frames and

* The "Richardson" seamless door, made by the Thorp Fire-proof Door Company, Minneapolis, Minn.

† Made by the United States Metal Products Company, New York City.

doors are made of metal-covered wood. Bronze is the metal usually recommended and preferred although Kalamein iron may be substituted when a much cheaper construction is necessary. This cheaper metal may be painted and will give fair service but it is not recommended. Galvanized iron and copper, also, are used.

"Window-frames and sashes of Kalamine or of sheet-metal over wood cores, are principally used for windows or skylights where the only danger of fire-contact is through flying sparks. They are non-combustible rather than fire-resisting. The lights are usually of plate glass, especially if Kalamine trim is used simply to comply with the law in those cities where non-combustible windows and doors, etc., are required in buildings of a certain class or of a height above fixed limits. Previous mention has been made of their efficiency as demonstrated in the burning of the Kohl building in San Francisco, and their value, even as a substandard protection, has been pointed out; but for efficient fire-resistance, Kalamine windows, especially, are an unknown quantity, as the resistance offered by the lighter members, such as sash-rails, is questionable. The better examples of the work present pleasing workmanship and finish. If some composition could be used for the body instead of wood, without producing chemical action harmful to the metal, a superior type of Kalamine work would result which would be of great value." *

Among the most excellent types of this construction are the bronze-covered window-frames and sashes † made according to the following details:

The cores for all exterior windows are of white pine, free from sap, shakes, loose or large knots, cut from selected stock and of the thicknesses, when milled, given in the following schedule:

Sills	2¾ inches double-rebated	sound, knotted, box pine.
Back-linings and head-linings	⅝ of an inch	sound, box pine or No. 1 common cypress.
Parting-strips	⅝ by 1⅛ inches	sound, box pine or No. 1 common cypress.
Pulley-stiles	1⅛ inches	shaky, clear, white pine.
Outside casings	1¼ inches	shaky, clear, white pine.
Inside casings	⅞ of an inch	shaky, clear, white pine.
Hanging stiles (molded)	1½ by 1½ inches	shaky, clear, white pine.
Sash-stiles and top rails	2⅛ by 2½ inches	shaky, clear, white pine.
Sash bottom rails	2⅛ by 4½ inches	shaky, clear, white pine.
Sash meeting rails	2 by 2½ inches	shaky, clear, white pine.

The cores are milled and constructed in the most approved manner, according to full-size details, have sash-joints screwed together

* "Fire Prevention and Fire Protection," by J. K. Freitag.

† Made by the United States Metal Products Company, New York City.

with 5-inch screws, that are countersunk beyond the surface of the edge of the stiles, and are arranged for inside glazing with loose glazing-beads, set with screws, not nailed. Before the pieces are assembled each piece is twice dipped in a bath of linseed-oil which at each dipping is allowed to soak thoroughly into the pores and fill them. The bronze-metal covering is made of an 85-per-cent-pure-copper and 15-per-cent-alloy mixture, free from fire-scales, tightly drawn over all exposed surfaces of the frames and sashes and properly locked. For the sills No. 20-Stubbs-gauge thickness is used; for the rest of the frame-members, except the loose moldings, No. 22-gauge, and for the sashes and loose moldings No. 24-gauge. Particular attention is paid to the brazing of the exterior joints, to make them thoroughly weather-proof.

For all sashes in frames measuring over 4 feet in width, both the top and bottom meeting-rails and also the top rail of the top sash, are reinforced with a 1/8 by 1 1/2 by 1 1/2-inch iron angle, sunk into the cores and underneath the metal covering, turned up or down at the joining of the stile and rail, and screwed to the stile under the glass molding.

The frames are usually built into the brickwork as the walls go up, and are properly braced and anchored on each side with two iron anchors that are turned down into the brickwork and calked with oakum under the hanging stiles, before these are screwed into place. The sashes are hung on roller-bearing, bronze-faced pulleys, with heavy bronze-metal chains and sectional, iron weights and connections. Should metal weather-strips be desired, the sashes are grooved to receive them. These frames and sashes never require painting, are extremely durable and fulfill the building regulations of most cities.

269. EXAMPLES OF KALAMEIN-IRON-COVERED DOORS, SASHES AND TRIM. Figs. 418,* 419,* 420* and 421* are typical examples of the Kalamein-iron-covered work which is sometimes designated "semiretardant" because of its noncombustible character. Fig. 418 shows the elevation of a Kalamein-iron-covered, single-paneled door and a section through its stile, panel and moldings and through the Kalamein-iron-covered frame and trim. The stiles, rails, moldings, jambs, head and trim are of drawn iron over wood cores; the single panel is of solid steel. The panel-moldings are applied separately. The frame and trim is arranged for a wooden-buck construction in a terra-cotta-block partition. Fig. 419 shows the elevation and sections of a Kalamein-iron-covered sash door and trim and sections of door, trim and frame. The two panels are stamped over a wood core and are

* Courtesy of the United States Metal Products Company, New York City.

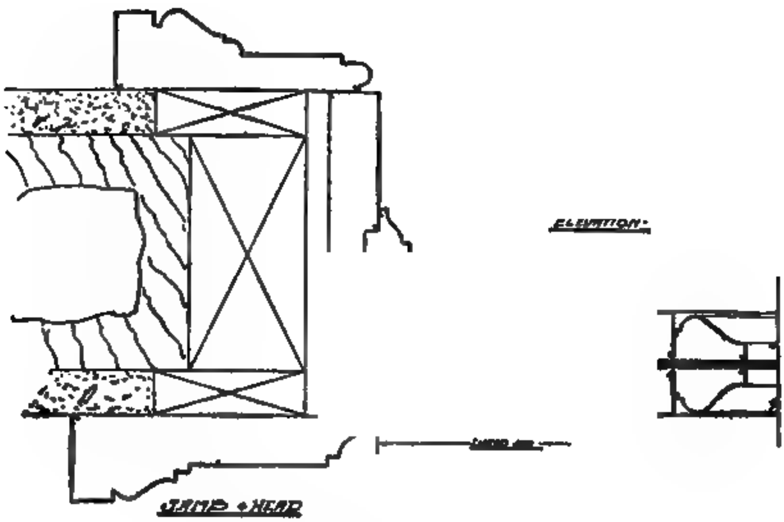


Fig. 418. Kalamein-Iron-Covered Single-Paneled Door, Frame and Trim.

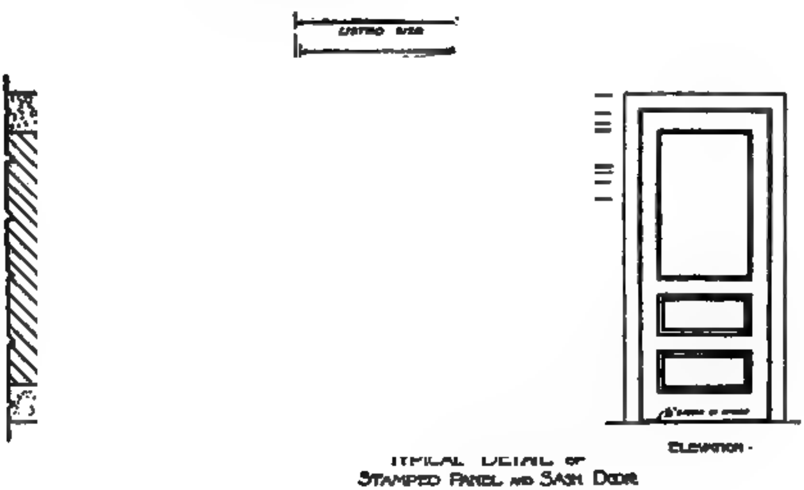


Fig. 419. Kalamein-Iron-Covered Sash-Door, Frame and Trim.

continuous with the rails, stiles and panel-moldings; the sash-moldings are applied separately. The partition-section shows a wood buck in a brick wall. Fig. 420 shows detail sections of a typical metal-covered double-hung window-sash and frame in a masonry wall. The wood cores may be covered with Kalamein iron, bronze or copper, the metal covering the sill, jambs, head, moldings, stops, parting-strips, sashes, etc., and running back into the reveals as

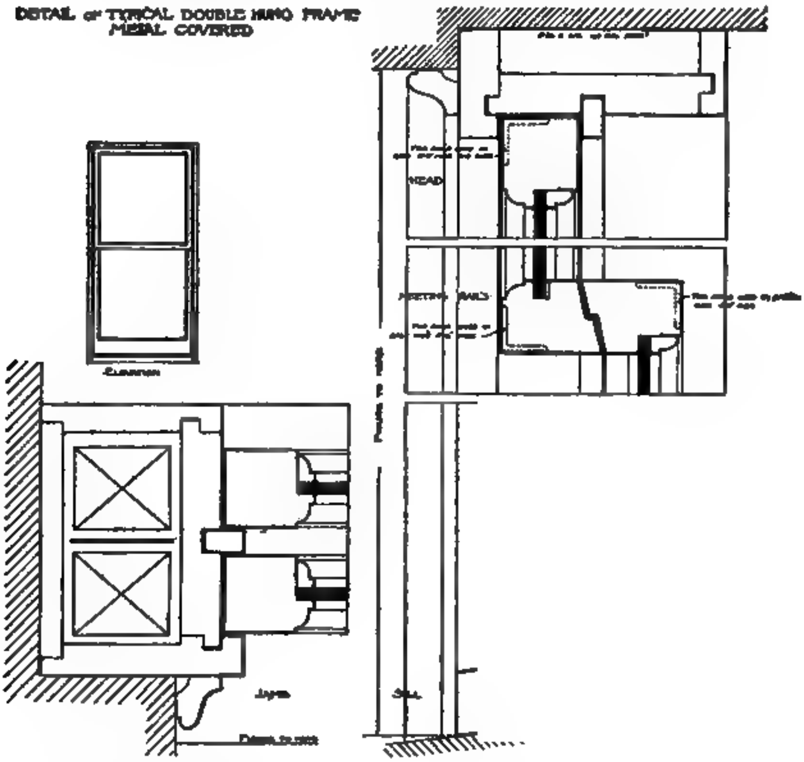


Fig. 420. Kalamein-Iron-Covered Double-Hung Window-Sash and Frame.

shown. The moldings on the outside face of the sashes are continuous with the stiles and rails but those on the inside face are applied separately to allow for the setting of the glass. When the sashes are over 4 feet wide a steel angle is set inside the metal covering on the inside upper edge of the meeting-rail of the lower sash; when over 4 feet 6 inches wide, another steel angle is used in the lower outside edge of the meeting-rail of the upper sash; and when over 5 feet wide, still another angle, on the upper outside edge of the top rail of the upper sash. Fig. 421 shows sections of

metal-covered casement-sashes hung to swing in. The construction of the rails and stiles and of the frame is similar to that of the double-hung window-sash.

270. HOLLOW-METAL DOORS, SASHES, TRIM, ETC.* The transition from metal-covered wood to hollow sheet-metal for doors, sashes, frames and trim, moldings, etc., was naturally and easily made and to-day the latter type of construction when expertly carried out results in details for interior work which are very effi-

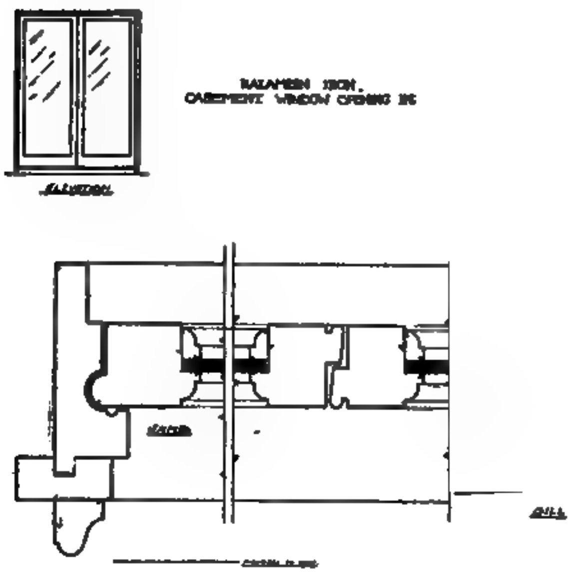


Fig. 421. Kalamein-Iron-Covered Casement-Window Sash and Frame.

cient to resist fire and handsome in appearance. It would be difficult to devise constructional details which would be more satisfactory and at the same time present greater possibilities in the way of elaborate design and high finish; and it is on account of all these advantages that this type of construction is used in the interior equipment of many of the best examples of fire-resisting buildings, especially for the doors, frames, sashes and trim of corridors, hallways and stair and elevator-enclosures and even for entire office-partitions. Because of the non-absorbent character of the baked-enamel finish this material is particularly sanitary; and

* Among the better known manufacturers of hollow, sheet-metal doors, trim, etc., are the Dahlstrom Metallic Door Company, Jamestown, N. Y., the United States Metal Products Company, New York City, and the Art Metal Construction Company, Jamestown, N. Y.

hollow-metal doors are easier to clean than any others, especially if all moldings are omitted and the panels made simply as smooth depressions. The thickness of standard hollow-metal doors approved by underwriters, varies from 1½ to 2⅛ inches.

271. HOLLOW-METAL DOORS. The Dahlstrom patent sheet-metal door * is made from two No. 20 gauge, steel plates, one stile and one panel-face being formed from each of the sheets, which are connected by interlocking seams on opposite sides of the

Angle-Iron Frame Construction

Wood Buck Construction

Fig. 422. Typical Dahlstrom Door, Frame, Trim and Jamb Construction.

panels and make practically a double door. Fig. 422 shows a section of a typical Dahlstrom door, the metal frames, four styles of trim and two methods of securing the frames to a wall. One method is by a steel angle-frame and the other by a wood-buck construction. In constructing the panels they are first lined with a sheet of asbestos next to the steel on each side, and the space between is filled with a layer of hair-felt paper, which makes a resilient filling that is a non-conductor of heat. The stiles are left hollow but strips of cork are laid perpendicularly across the center of each to deaden the metallic ring. The panels are then attached

* Made by the Dahlstrom Metallic Door Company, Jamestown, N. Y.

to each other to form the door by planting on and welding in place properly formed cross-rails, at the top and bottom, and wherever else they may be desired; the moldings are coped over the molded stiles at the sides. The top and bottom edges of the door are then reinforced with channels and bars, and the doors made perfectly straight and rigid. The fire-resistance of this construction is increased by letting no rivets or screws pass through from one side of the door to the other in the exposed parts. The transmission of heat is thus avoided.

While the door is being put together, provision is made for attaching the hardware. All hollow-steel doors of the Dahlstrom make are reinforced for hinges with 3/16-inch wrought, machine-steel pieces, that extend the full width of the door from edge to edge on the inside immediately back of the butts. These reinforcing-pieces are counter-sunk with a heavy hydraulic press a sufficient depth to make them fit flush with the finished door. They extend 4 inches above and below the butts and are welded to the steel door. They are then drilled and tapped to receive the butts. The reinforcing for locks can be done in two ways: A stamped-steel casing can be used, which will completely cover the lock on all sides and have a body large enough to receive it and hold it rigid. The sides are extended to touch the inside edges of the door and are electrically welded to it, so that they form a complete "box" with the necessary holes drilled in its sides to receive the spindles, key-holes, cylinders, etc. A second method is to have this box made up into what is known as a "cast-iron spider," in which the body of the lock may sit snugly. The cylinder-holes, spindle and key-holes may be either cast in it or drilled in it after it is set in the door. It is necessary to have lugs cast on these spiders to fit neatly between the inside rails of the door. When required, the locks can be drilled and tapped to receive the escutcheons, etc. Door-checks, door-holders, letter-plates, etc., are applied to 3/16-inch U-shaped pieces, and electrically welded to the door. These pieces are large enough to receive the different pieces of hardware and have the necessary drilling and tapping to receive them.

After the doors have been put together, they are sent to the finishing-department where the steel is thoroughly cleaned from all rust, grease or other impurities. They are then given six or eight coatings of enamel, being baked after the application of each coat in large ovens which are heated to 300° Fahr. After the final coat of varnish is put on, they are usually rubbed to an egg-shell, gloss finish, equal in quality to any hardwood finish, and more durable because baked on. The surfaces can be grained to imitate

with wonderful exactness any wood, such as quartered-oak, mahogany, Circassian walnut, etc. If the doors are to receive glass

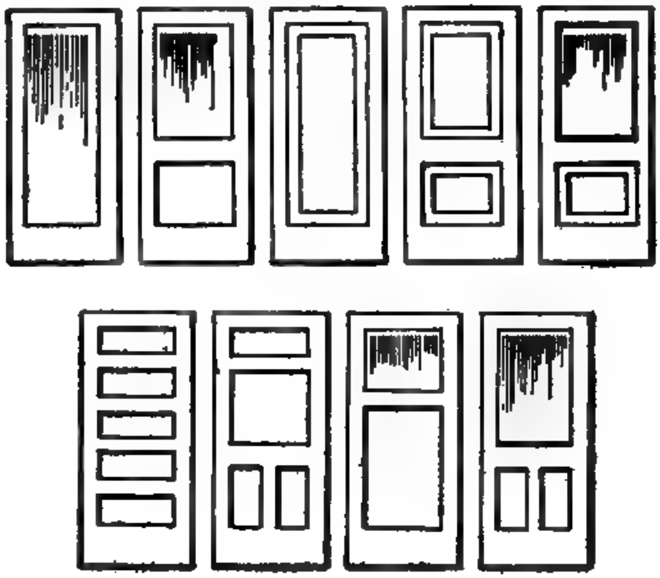


Fig. 423. Types of Dahlstrom Doors. Office-Door, Transom and Partition-Sashes.

panels they are provided with detachable moldings to hold the glass in place.

Fig. 423 shows types of Dahlstrom hollow-metal doors, some of which are made to receive glass panels. The lower illustration

shows a typical office-door with two horizontal panels below and one glazed panel above and with a transom over it. On each side is a partition-sash with glass. The door, frame, transom-sash, partition-sash and trim are all of hollow metal. The hardware including the butts, lock and knob, letter-slide, transom-lift and door-check are shown attached to the metalwork. Doors of the Dahlstrom, metallic type are installed in the corridors and partitions of the Singer building and tower and the United States Express building, New York City; the Bell Telephone Exchange building, Philadelphia; the Seventh Regiment Armory, Chicago; the Pontchartrain Hotel, Detroit; the Bank of Commerce building, St. Louis; the First National Bank building, Denver; the Royal Insurance building, San Francisco; and many others.

The United States Metal Products Company makes two kinds of hollow-steel doors, known as "type A" and "type B." Both kinds are the same in general appearance and differ only in construction. Type A, shown in Fig. 424, has a complete inside lining of asbestos; type B, shown in Fig. 425, has single-thickness sheet-steel panels, with a partial asbestos lining in the stiles and rails to prevent reverberation.

The steel used in the construction of these doors is a specially prepared patent leveled furniture stock of a very high grade, No. .050 in thickness for stiles and rails. It is shaped to the required profile by powerful presses. The panel-moldings, which are cold-rolled in steel of slightly thinner gauge, are continuous on both sides of the door; the panels fit in a groove formed in the moldings which are process-welded at the miters. The connecting edges of the stiles, rails and moldings are so formed that they are, when assembled, locked together with a continuous metal-key strip, which is pneumatically forced into place. Neither the molding nor the panels, therefore, can be removed without destroying the entire door. A special arrangement is provided for glass panels by a loose molding on one side of the door. The joints between the stiles and rails and all the other joints are hermetically welded by the "universal process," for which this company holds the patent rights, and make a homogeneous structure whose joints or miters will open up to no force other than one of actual violence. Plates and reinforcing-blocks are welded on the interior of the doors to receive hardware, which is machine-screwed in place at the factory after the doors are enameled.

Among the many buildings that have been equipped with these hollow-steel doors may be mentioned, in New York city, the Woolworth building, the Germania Life Insurance building and the Ritz-Carlton, McAlpin and Vanderbilt hotels; in Cleveland, the

Rockefeller building; in Boston, the Jordan-Marsh building; in Duluth, the Soo building; in Worcester, Mass., the Worcester County Court House; and in San Francisco, the First National Bank building. In some of the buildings mentioned in this article and that immediately preceding it, hollow-metal doors, trim and moldings are accompanied by bronze or other metal-covered wood window-frames, sashes, etc.

272. HOLLOW-METAL DOOR-FRAMES, TRIM AND MOLDINGS. After the hollow-metal door reached an advanced stage of construction the manufacturers turned their attention to

Fig. 424. Hollow Steel Door with Asbestos Inside Lining.

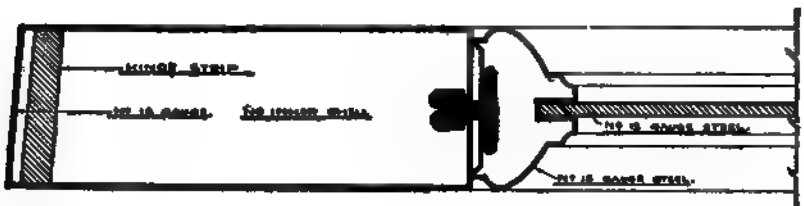


Fig. 425. Steel Door with Hollow Stiles and Rails and Single-Thick Sheet-Steel Panels.

the problems involved in making metal frames and moldings. It was found that moldings made by the ordinary hot-rolled process were too rough and heavy and required too much labor to smooth and finish their surfaces; and that those pressed from light-gauge steel by the common methods were not clear-cut and definite in their outlines and were limited in length and in variety of shapes.

Accordingly, what is known as the "cold-drawn" method of making frames, trim and moldings was developed and perfected, and moldings made by this process are now used for many kinds of interior work. The cold metal is drawn through special dies to give it the required shape and the bright finish is retained. The corners and angles come out sharp and true and the pieces possess much greater strength and rigidity than those hot-rolled and several times thicker. There are dies for over a thousand shapes. Moldings can now be made in lengths up to 40 or even 50 feet, but extra freight-rates and other drawbacks make it inadvisable to ship it

in lengths of over 20 feet. Besides the cold-rolled special high-grade steel, brass, bronze and copper are used in their manufacture. The rolled shapes include angles, channels, Z bars, and moldings for bases, cornices, wire-conduits, door-jambs, sash-bars, panels and glass, picture-frames, door and window-casings, trims of all kinds, wainscoting, chair-rails, and numerous miscellaneous sorts.

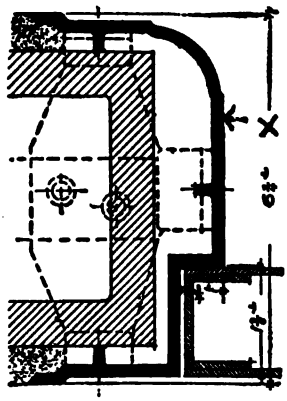


Fig. 425a. Wrought-Iron Welded Door-Frame.

Wrought-iron welded one-piece door-frames are made for use in fire-proof partitions. Fig. 425a * shows a jamb-detail of a door-frame of this type. These frames are constructed scientifically of specially rolled wrought iron in several different shapes. The mitered corners are welded together making the frame one solid piece. They are made for any thickness or type of door or partition, require no bracing and can be fitted with invisible hinges if required.

273. HOLLOW-METAL WINDOW-FRAMES AND SASHES. Hollow-metal window-frames and sashes, as well as those which are made of metal-covered wood and of cast iron, wrought iron, drawn bronze, cast bronze, etc., and glazed with wire-glass, prism glass, electroplated glass, etc., are used in those parts of buildings in which the exposure to fire is not great enough to require the use of hinged or rolling shutters, or where a more pleasing appearance is demanded than that resulting from the use of hinged or rolling fire-shutters. Owing to many improvements made in recent years, both in design and details of manufacture, hollow, sheet-metal window-frames and sashes are now ranked among the best types of those of moderate cost for general use. The National Fire Protective Association, by their recommendations and standardizations, and the tests and labeling-systems of the underwriters' laboratories have been largely instrumental in bringing about these improvements and results. It is stated that these laboratories have (up to the year 1912) approved from one to eighteen types of these windows for each of sixty-seven manufacturers. This puts twenty-two distinct types in use. About the only disadvantage connected with the use of sheet-metal windows is a relatively rapid deterioration when neglected.

The materials used for making hollow-metal window-frames and sashes are galvanized iron or steel; copper; sheet metal, copper-

* Manufactured by J. G. Braun, New York City.

plated; and sheet metal, bronze-plated. The sashes are glazed with plate or maze wire-glass where good appearance is an essential requirement or with ribbed or rough wire-glass where a translucent material only is desired. Of course, clear glass, unwired, may be used when additional fire-resistance is not the object. The National Board of Fire Underwriters fix, within certain limits, the various constructional details, the maximum permissible sizes of openings for glass, etc. The principal regulations have been very conveniently condensed by Mr. J. K. Freitag,* and are as follows:

"*Maximum Size of Frame.* Metal frame containing the sash or glass not to exceed 5 feet by 9 feet between supports.

"The above size is designed to take the maximum glass-sizes with allowance for the metal parts and is as large as can be safely permitted.

"*Size of Glass.* (a) The unsupported surface of the glass allowed shall be governed by the severity of exposure, and be determined in each case by the underwriters having jurisdiction, but in no case shall it be more than 48 inches in either dimension nor exceed 720 square inches.

"(b) The glass to be of such dimensions, after selvage is removed, that the bearing in the groove or rabbet is not less than 5/8 of an inch.

"*Material.* (a) To be of at least No. 24-gauge galvanized iron and of a quality soft enough to permit all necessary bending without breakage. The galvanizing not to flake nor break badly in bending.

"This applies to all parts of the frame and sash.

"Experience has demonstrated that a metal too light to insure a substantial and durable frame is liable to be used, particularly in the larger frames.

"(b) To be of 20-ounce or heavier where copper frames or sash are used.

"The copper frame is not considered the full equivalent of the iron frame as a fire-retardant on account of the comparatively low fusing-point of copper. In localities subject to unusually corrosive atmospheric influences and where galvanized iron will rust out rapidly, the copper frame may be recommended providing the exposure is not extreme. The copper frame should not be used in elevator-shafts, ventilators, partitions or where liable to be subjected to intense, internal fires.

"Various types of hollow-metal windows include sash arranged as follows:

"*Stationary.* Hinged upper, stationary lower. Also with stationary, pivoted or hinged transom.

"*Casement.* Double-hung. Also with stationary, hinged or pivoted transom.

"*Pivoted.* Single sash, top and bottom pivots.
Upper and lower sashes pivoted.
Upper sash side-pivoted; lower sash stationary.
Lower sash side-pivoted; upper sash stationary.
Pivoted middle sash; upper and lower, stationary.
Upper, middle and lower sashes pivoted.

* "Fire Prevention and Fire Protection," by J. K. Freitag.

Pivoted upper; two lower, stationary.
Pivoted upper and lower; middle, stationary.
"*Combination.* Pivoted upper sash; double-hung lower sash."

Approved hollow-metal window-frames and sashes of one type * are constructed as follows:

Frames. The window-frames are made of No. 22 galvanized steel. All frames have a staff-molding of a standard design, and have a 1-inch fin. The staff-molding and fin are formed in the jamb. The parting-strip has a channel-shaped weather-strip made of the same gauge steel and is fastened to the parting-strip with small, round-head bolts inserted at distances not less than 9 inches on centers. The sash-runs are so arranged that the weight-pockets will not in any way interfere with the working of the sashes. The cover of the weight-pockets is attached to the sash-runs with two countersunk bolts and the sash-runs are countersunk to receive the sash-pulleys. The pulleys are fastened to the frame with countersunk bolts and all frames are delivered to the building with the pulleys in place. The entire frame is well clinched and riveted at all joints and soldered so that the frame is water-tight. Each frame has the underwriters' label, as well as the label of the manufacturer, on the inside of the sill.

The frames are well braced with two channel-shaped braces well soldered to the head and jamb. These braces are left in place until the sashes are to be hung, and are then removed by the contractor. All surplus solder is removed from the frames.

After the frames have been painted, the sills are filled with concrete, made of one part cement, two parts sand and three parts clean cinders, well grouted in place. For out-of-town shipments it is sometimes advisable to fill the sills at the buildings in order to keep down the freight-charges.

Sashes. The sashes are made of No. 24 galvanized steel, with ¾-inch glass-rests. They have weather-strips arranged to interlock with the weather-strips of the frames; the sashes are well locked, clinched and soldered at all joints and made water-tight. The sash-locks, lifts and sockets are riveted to the sashes. The chain-ears are fastened to the sash-rails with not less than two rivets to each ear.

Muntins. Where muntins are shown, they are made of No. 24-gauge galvanized steel, well clinched to the sashes and soldered in place.

Hardware. The pulleys are of cast iron and are roller-bearing. Lifts, locks and sockets are made of malleable iron, to fit the sashes, and are riveted in place. The sash-chains are heavy steel, galvanized. Weights are of the sectional pattern of cast iron and of such weight as is necessary to balance the sashes.

Mullions. Where mullions are required they are constructed in accordance with the underwriters' requirements for mullioned windows.

Painting. All parts of window-frames and sashes, whether exposed or not, are painted with one coat of approved paint at the factory before shipment.

* **Made by the United States Metal Products Company, New York City.**

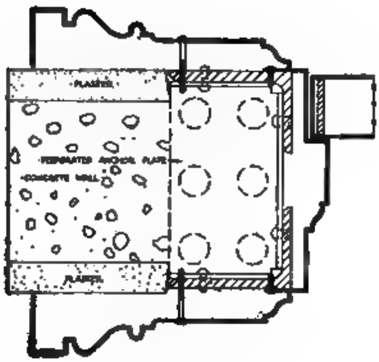


Fig. 426. Hollow-Metal Door and Trim. Concrete Wall. Plate-and-Angle Buck.

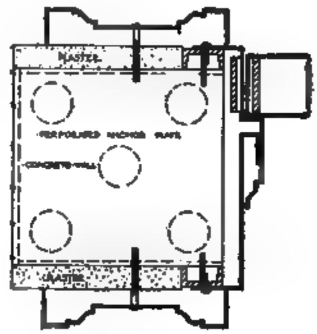


Fig. 427. Hollow-Metal Door and Trim. Concrete Wall. Plate-and-Channel Buck.

Fig. 428. Hollow-Metal Door and Trim. Tile Wall. Channel-Buck.

Fig. 429. Hollow-Metal Door and Trim. Tile Wall. Wood Buck.

Fig. 430. Hollow-Metal Door and Trim. Plaster Partition. Wood Buck.

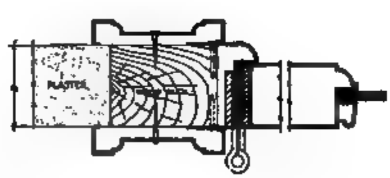


Fig. 431. Hollow-Metal Door and Trim. Plaster Partition. Wood Buck.

274. EXAMPLES OF HOLLOW-METAL DOORS, FRAMES, SASHES AND TRIM. Figs. 426* to 437* are typical examples of hollow-metal doors, frames, sashes and trim and also of various methods of constructing jambs and bucks in walls and partitions built of various materials.

Fig. 426 shows a hollow-metal door, frame and trim in a concrete wall or partition. The frame and trim are secured by screws to vertical, steel angles which are themselves screwed to horizontally placed steel, anchor-plates, built into the concrete wall and perforated as shown to afford a clinch or anchorage in the concrete. The hollow-metal frame is in one piece rebated to receive the door. Fig. 427 shows a larger square, perforated-metal-plate buck with two small, steel channels at the jamb on the wall-sides of the partition. The frame is in two pieces as shown and is secured to these channels with screws, the channels and trims being screwed to the turned-up wall-edges of the plate. Fig. 428 shows a hollow-metal stamped-panel door, one of a pair of hinged, folding doors; a section through the meeting-mold which is fastened to one door; the butt-jamb; and a steel-channel-buck construction secured to a tile partition by an expansion-bolt. The only trim, aside from the frame is the angle-mold in the jamb. Fig. 429 shows a hollow-metal door arranged for a glass panel. The butt-side of the jamb is illustrated, with tile partition and wood-buck construction. The frame, which is in one piece, is screwed, together with the trim, to the wood. Fig. 430 shows a hollow-metal stamped-panel door, butt-jamb, 3-inch plaster partition with wood-buck construction and metal frame in two pieces to form rebate for door. The trim and frame are screwed to the wood. This drawing, as well as the others with the butt-jamb, illustrates the method of countersunk reinforcing of the door and frame for the butts. Fig. 431 is for a construction somewhat similar to that shown in the preceding figure except that the partition is only 2 inches wide and the frame in one piece, rebated. Fig. 432 shows a wide terra-cotta partition with wood buck, grounds, and one-piece hollow-metal frame with trim and glazed door. The frame is in one rebated piece, screwed to the wood buck and the trim is lapped over it and the plaster and screwed to the wood grounds. Figs. 433 and 434 show hollow-metal door, window-frames, trim, mullion, etc., for corridor, tile partitions in an office-building. The partition-jamb bucks are formed with steel channels and angles screwed together as

Fig. 432. Hollow-Metal Door and Trim. Tile Wall. Wood Buck.

* Courtesy of the Dahlstrom Metallic Door Company, Jamestown, N. Y.

shown. Adjustable metal clips are furnished with these bucks to fur out to the proper distance the frames and trim which are screwed to them. The construction of the partition between the door and partition glazed frames is clearly shown. The glass is held in rebated one-piece hollow-metal frames

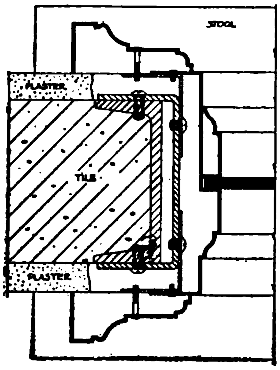


Fig. 433. Hollow-Metal Window-Frame and Trim with Channel-Buck for Tile Partition.

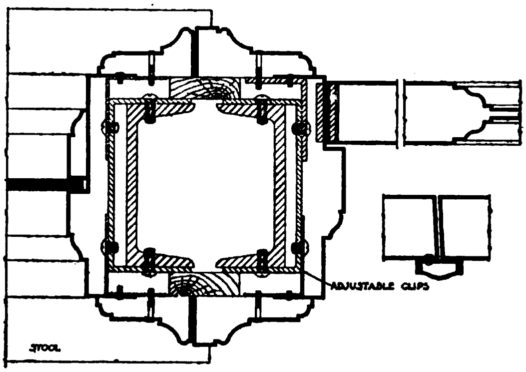


Fig. 434. Hollow-Metal Door, Trim and Window-Frame with Channel-Bucks for Partition-Mullion.

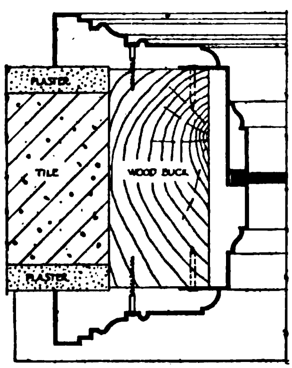


Fig. 435. Hollow-Metal Window Frame and Trim with Wood Buck for Tile Partition.

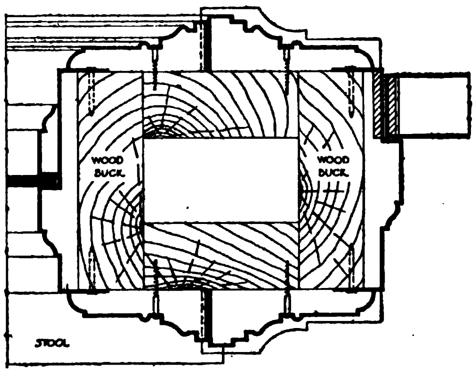


Fig. 436. Hollow-Metal Door, Trim and Window Frame with Wood Bucks for Partition-Mullion.

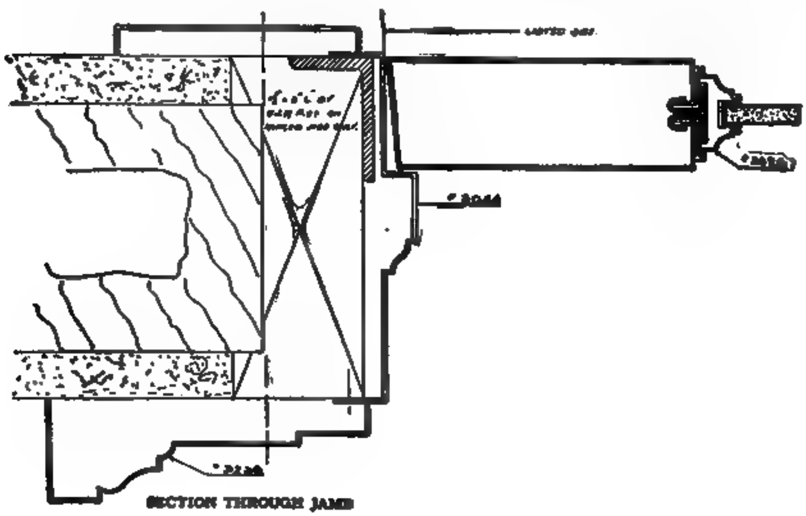
by removable moldings. The meeting-stiles of hinged, folding doors with meeting-molding are also shown. Figs. 435 and 436 show a wood-buck construction for doors, partition borrowed lights, partition mullions, etc., similar to those shown in Figs. 433 and 434. Fig. 437 illustrates the type of hollow-steel doors, transoms, glazed frames, trim, etc., used in the partitions between the corridors and offices of the United States Express building, New York City. The elevation shows both the corridor and office sides of the partition, door, transom and glazed frames. Section *A* is taken through

the bottom rail, panel and panel-mold of the door. Section *B* is taken through the middle rail, the steel and glass panel-molds and the letter-drop, and indicates the method of securing the latter to the hollow-steel rail. The elevation of the letter-drop hood, also, is shown. Section *C* is taken through

Fig. 437. Hollow-Steel Door and Side-Lights in Corridor-Partitions. United States Express Building, New York.

the upper rail of the door, the transom-bar and the lower part of the transom-sash. Section *D* is taken through the upper part of the transom-sash and the transom-head. The transom-sash is pivoted in the middle to swing in at the top, and shuts against a rebated one-piece hollow-steel frame which is screwed to the wood side and head blocks. Section *E* is taken through

the knob-stile of the door, the mullion and the side-light frame. For the interior of the mullion and side-light bucks 7/8 by 2¾-inch wood pieces are used, with horizontal wood blocking added in the mullions. The metal frames are screwed to the vertical wood pieces or bucks, and the trim is screwed to the horizontal blocking. In connection with Section *E* is a horizontal section through the knob and hinge or butt-stiles and the glazed panel of the door. Section *F* is taken horizontally through the transom-sash, frame and mullion at the sash-pivot, and section *G* is through the side-light jamb. Section *H* is taken through the office hollow-steel base and the cor-



ELEVATION

Fig. 438. Hollow-Steel Trim and Door with Solid-Panel. Tile Partition. Wood Buck.

ridor, marble wainscot-base; the former is made in two pieces, screwed to the wood grounds, and has a hollow-metal quarter-round mold, screwed through the base at the floor-angles. Section *I* is taken through the side-light sill, stool and apron. The hollow-metal stool is in two pieces in the width of the partition, laps under the moldings of the side-lights and finishes over the face of the corridor, marble wainscot. The metal apron on the office side is in a separate piece, and is screwed to the wood ground under the wood sill-block. The moldings securing the lower part of the glass of the side-lights are screwed to the metal stools. The remaining section, *J*, is taken vertically through the wall-moldings; a hollow-metal picture-mold is shown on one side and a wire-mold on the other. Both molds are screwed to wood grounds and furring-blocks or strips as shown. The dimensions of all the details described above are figured or clearly shown on the drawings.

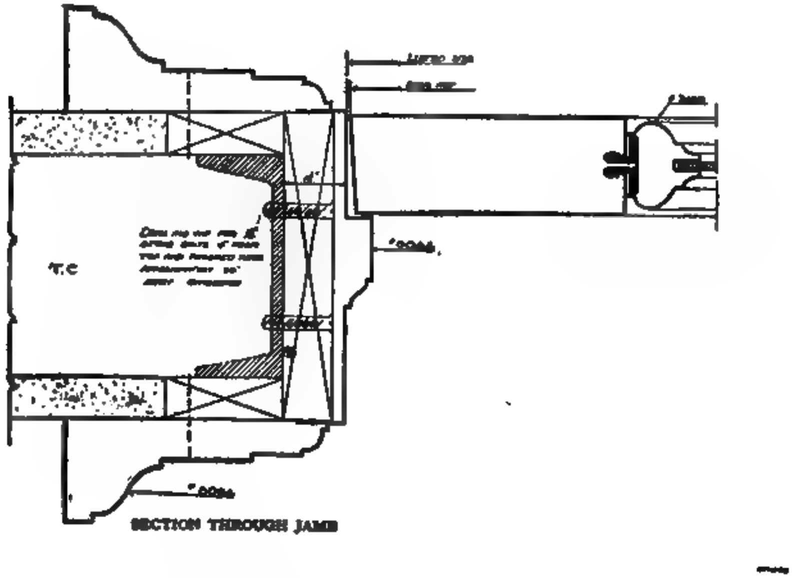


Fig. 439. Hollow-Steel Trim and Door with Solid-Panel. Tile Partition. Channel-Buck.

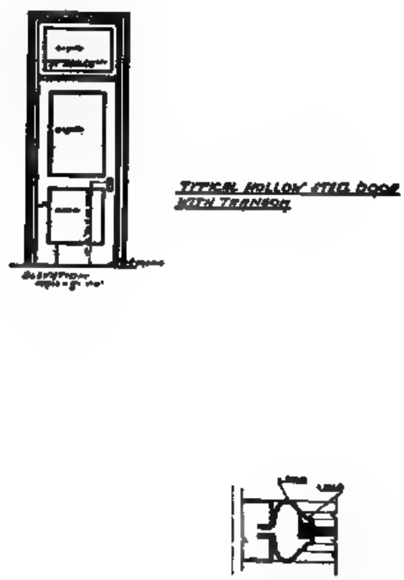


Fig. 440. Hollow-Steel Sash-Door and Transom. Tile Partition. Channel-Buck.

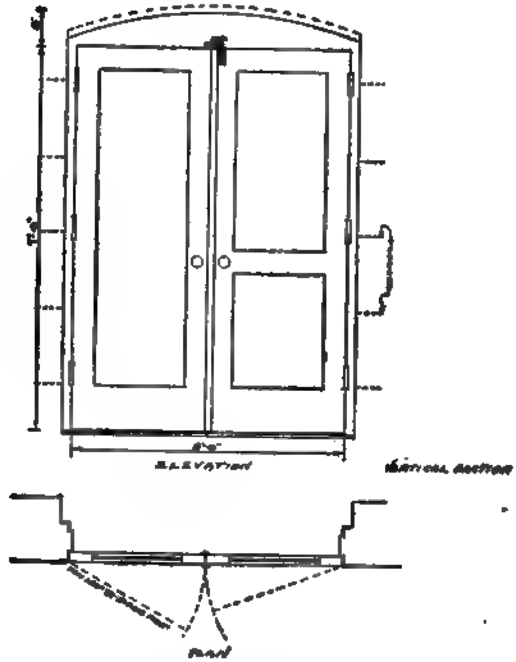


Fig. 441. Hollow-Steel Underwriter Door.

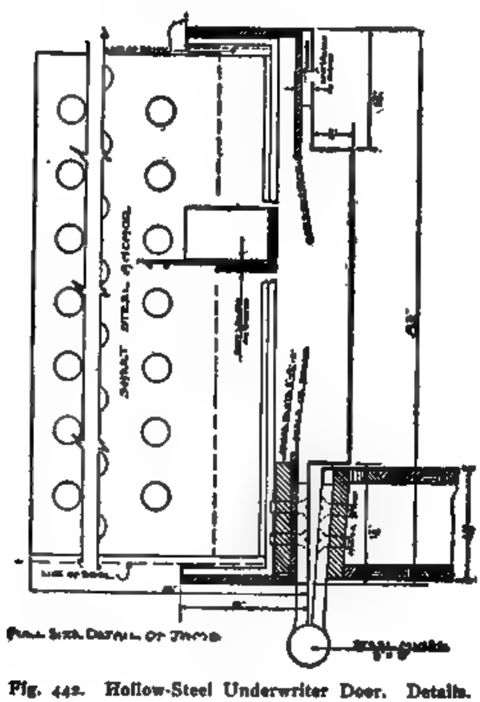


Fig. 442. Hollow-Steel Underwriter Door. Details.

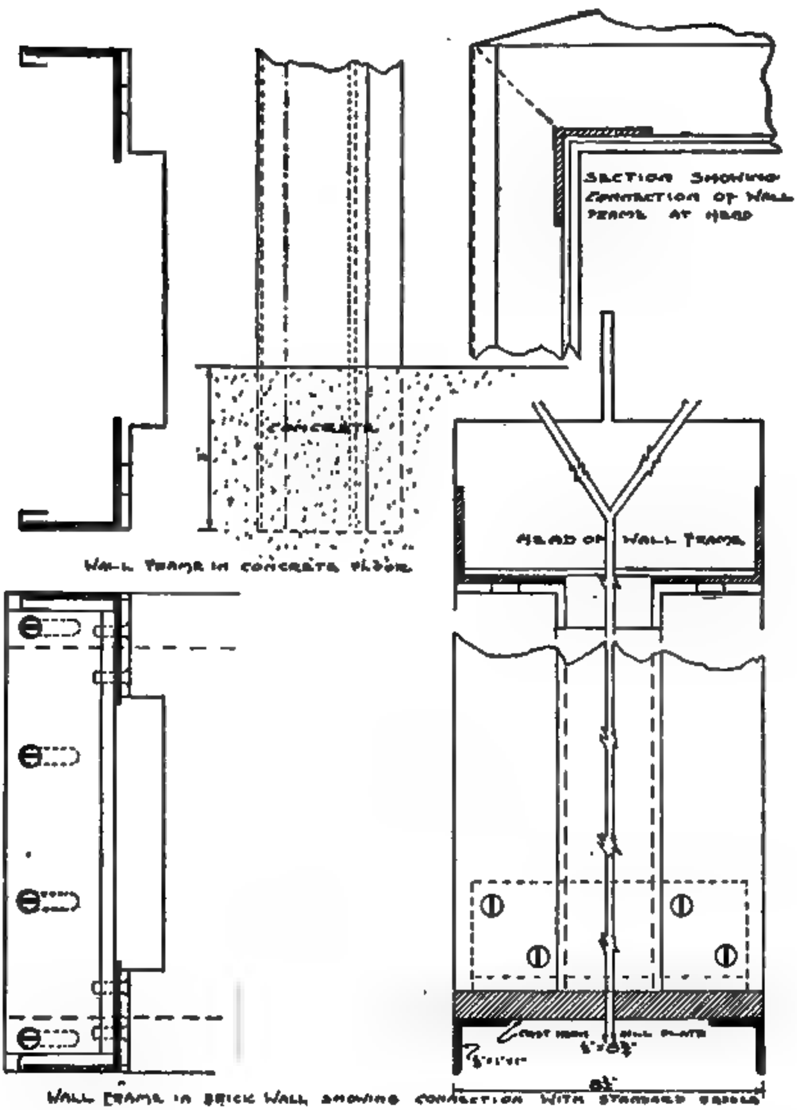


Fig. 443. Hollow-Steel Underwriter Door. Details.

The eleven illustrations,* from Fig. 438 to Fig. 448, are additional typical examples of hollow-steel doors, frames, sashes and trim, with variations in constructional details.

* Courtesy of the United States Metal Products Company, New York City.

Fig. 438 shows a hollow-steel, single, solid-panel door, rebated single-piece frame, two styles of trim and wood buck in tile partition. The wood buck is reinforced at the hinged side, only, by a 1½ by 2-inch steel angle. The key or fastening of panel-mold to stile is shown. Fig. 439 shows a hollow-steel single-panel door in tile partition, with wood grounds machine-screwed

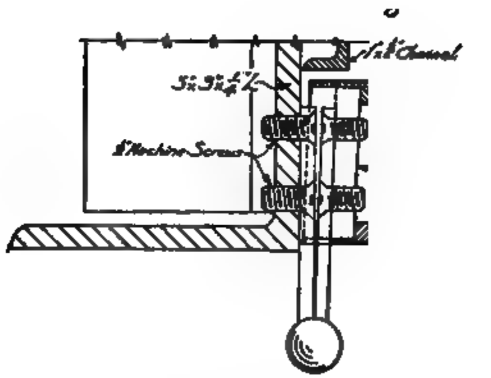


Fig. 444. Hollow-Steel Underwriter Door with Butt and Lock.

to a steel-channel buck, which is drilled and tapped for ¼-inch stove-bolts. These bolts are placed about 4 inches from ceiling and finished floor, spaced approximately 20 inches on centers, and staggered. The machine-screws securing the door-butts to the jambs continue into the channel-buck. Fig. 440 shows a hollow-steel sash door with transom in a tile partition and with steel-channel buck. The larger detail shows also the ½-inch saddle, transom-bar and sash-section and head jamb with channel support for tile over the opening. Figs. 441 to 444 show a hollow-steel "underwriter" door, in elevation, plan, vertical section, and constructional details. Fig. 442, a

horizontal section through the hinge-stile and hinge-jamb of this door, shows the perforated sheet-steel wall or partition-anchor, spot-welded or riveted to the jamb-angle; the corner angles of the frame, to which the hollow-steel frame is attached; the ¼ by 1¾ by 8-inch hinge-plate; and the 5 by 5-inch

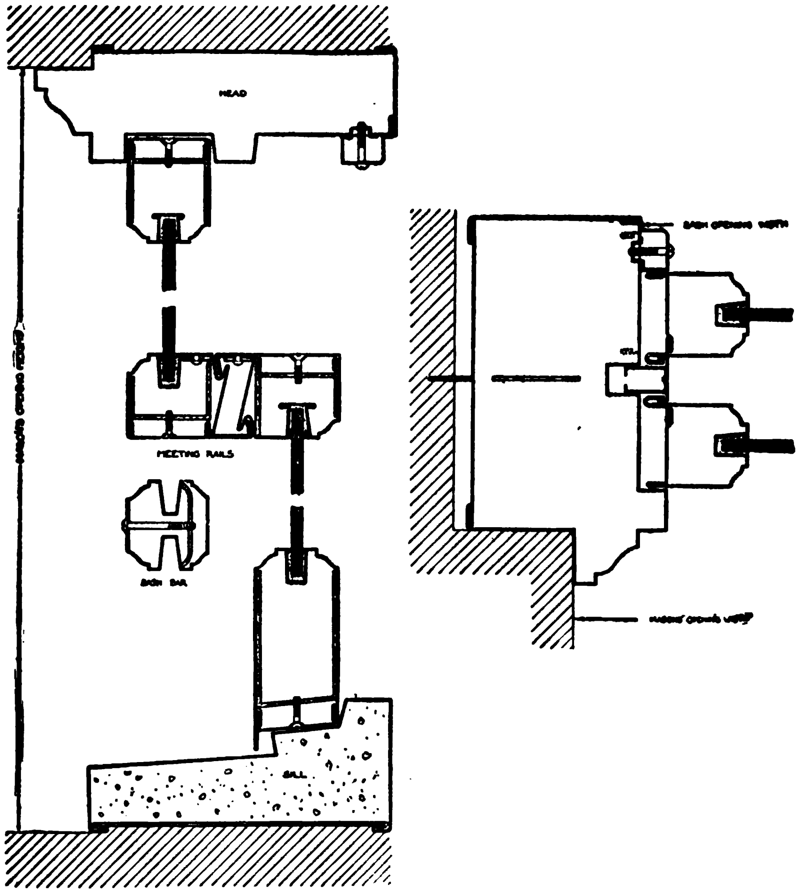


Fig. 445. Standard Hollow Galvanized-Iron Double-Hung Underwriter Window.

steel hinges. Fig. 443 shows the wall-frame in a brick wall with the connections with the standard saddle or cast-iron ½ by 8¾-inch sill-plate, the head of the wall-frame, and other details. Fig. 444 shows three horizontal sections through this hollow-steel underwriter door. The upper drawing is a section through the outer door-stile and through the steel panel and panel-mold; the middle drawing shows the meeting-stiles, meeting-moldings, "three-point locking-device" and automatic bolts; and the lower drawing shows the hinge or butt-stile of door, butt and butt-reinforcement and channel-buck jamb.

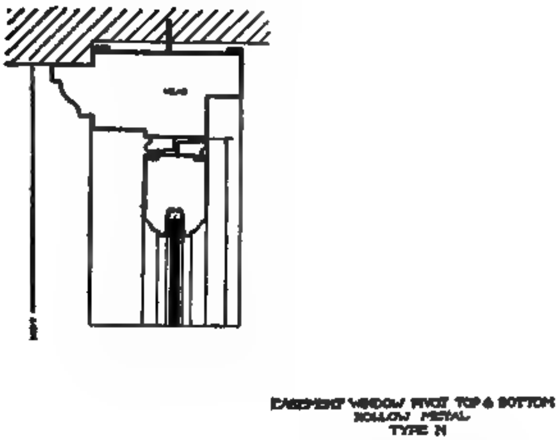


Fig. 446. Hollow Galvanized-Iron Window, Pivoted Top and Bottom.

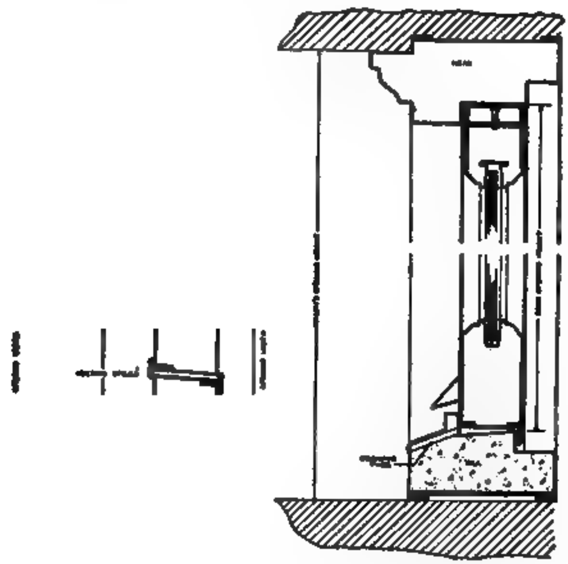


Fig. 447. Hollow Galvanized Iron Casement-Window, to Swing in.

Fig. 445 shows the standard, hollow, galvanized-iron double-hung, underwriter window, with vertical sections taken through the sill, sashes, meeting-rails and head and with a horizontal section through the sashes, frames and masonry jamb. The sashes are thoroughly reinforced with channel steel, the galvanized metal being formed around them as shown. The meeting-rails have an intermediate, locking, fire-resisting device. Sash-bars are shown with a middle reinforcing-piece held tightly in place by screws. Fig. 446

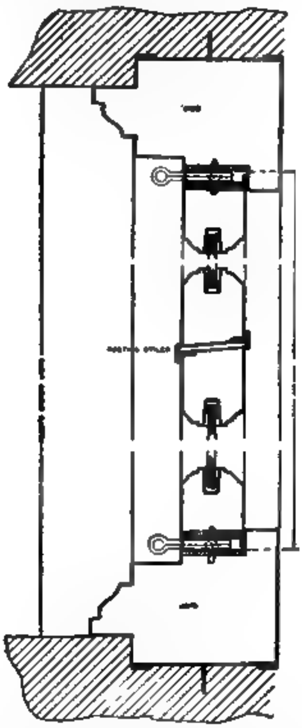


Fig. 448. Hollow Galvanized Iron Casement-Window, to Swing Out.

shows a hollow, galvanized-iron window-sash, frame and sill. The sash is pivoted at top and bottom. Fig. 447 shows casement-window sashes hinged to swing in and Fig. 448 casement-window sashes to swing out.

7. INSIDE SHUTTERS, INSIDE BLINDS AND COILING PARTITIONS.

275. INSIDE SHUTTERS. At one time inside shutters were considered among the necessary fittings of a fine dwelling, and when they are properly arranged they are very serviceable. When they interfere with the proper trimming of the windows by shades and draperies, however, they are more objectionable than

desirable. Therefore when they are used in rooms that are to be nicely furnished, the jambs of the windows should be made of such depth, by furring the walls if necessary, that pockets may be provided for the shutters to swing into when open, and the arrangement of the finish should be such that when the shutters are folded back they will look like paneled jambs. To obtain the best effect the windows should have panel-backs, with paneled jambs to the floor.

Figs. 449 to 451, taken from an excellent article on "Interior Woodwork," by Mr. A. C. Nye, and published in the *American Architect* of January 23, 1892, shows what is probably the most complete and desirable arrangement for inside shutters in dwellings.

The different folds of the shutter should be hung so that they will all swing in the same direction, the middle leaf always occupying a position near the center when the shutters are folded in the box. It is believed that this method of hanging corrects the tendency of shutters to spring out of the box.

One feature which may be noticed in Figs. 450 and 451 and which should always be provided, is that the top of the shutter is not carried to the soffit of the window, but is separated by a 1/4 or 3/8-inch bead. The bottom is similarly treated on the elbows and seat.

The location of the curtain-poles should be considered in laying out the drawing for the window. If they are to be set on the outside of the trim the casings may be set as close to the shutter-box as the thickness of the wall will permit. If, however, it is desired that the curtain be kept inside the trim, or if the shutter-box does not project sufficiently to clear the plaster-line of the wall, a fitting-piece must be used, as shown in Figs. 449 and 450, and the curtain-poles fastened to it. Should the fitting-piece be wide enough to receive both the heavy pole for drapery curtains and the small pole for lace curtains the latter is placed directly behind the former. If the curtain-poles are placed on a level with or a little below the soffit of the window, light shows above them. To avoid this the fitting-piece across the head should be kept 2 5/8 inches above the soffit of the window and the poles placed as in Fig. 450.

When it is desired to reduce the thickness of the wall, the jambs may be splayed, as shown in section in Fig. 453, and in elevation in Fig. 452. The window-finish may also be brought forward into the room if furring is objectionable, as shown in Fig. 456. Fig. 457 shows the details of the finish for a window with double-hung sashes and inside shutters folding into pockets at the sides. This is another of the many methods of providing pockets for inside

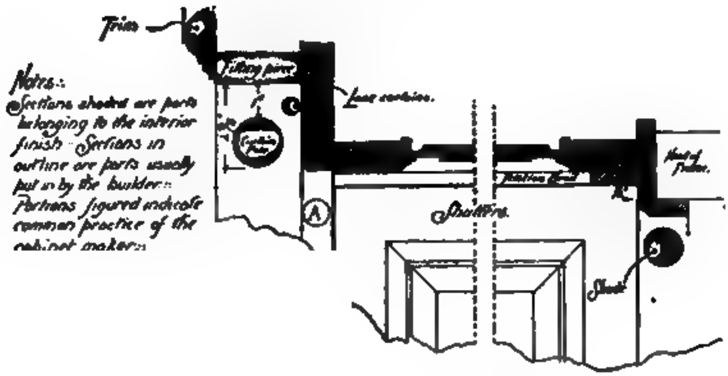


Fig. 450. Section Through Head of Window.

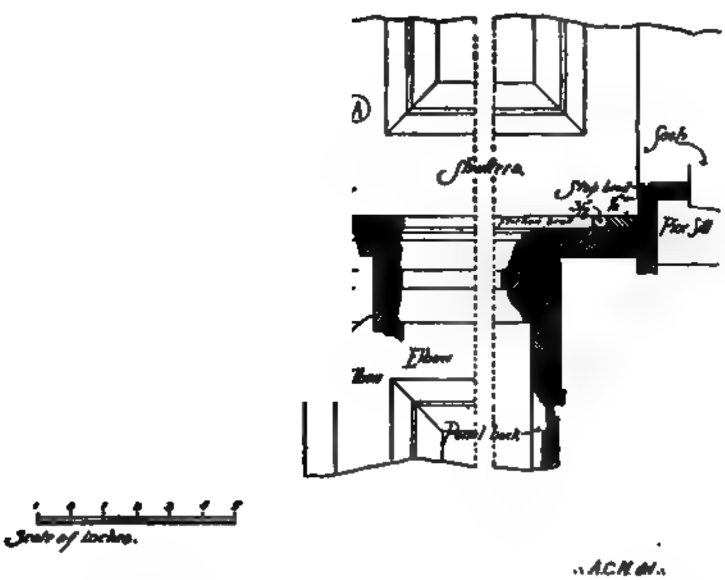


Fig. 449. Plan of Shutters. Fig. 451. Section Through Window-Stool.

shutters, the number of folds varying greatly according to conditions which control the window-trim. In this example there is a deep reveal on the exterior and heavy furring on the interior to avoid building the shutter-boxes out into the rooms beyond the face of the plastered walls.

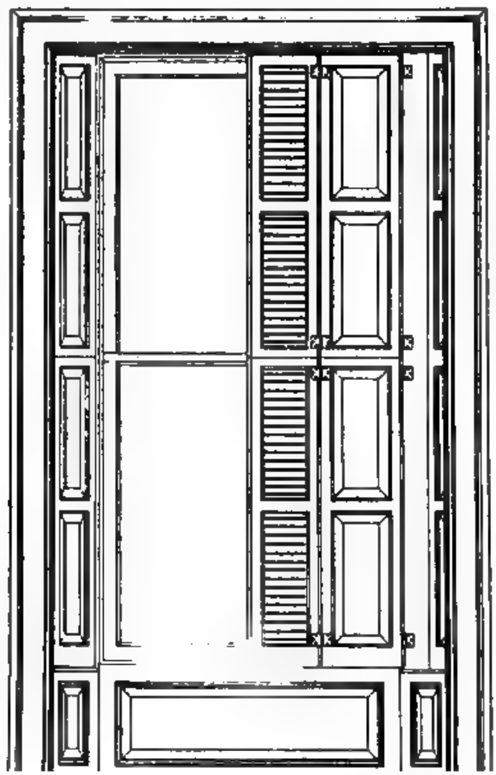


Fig. 452. Inside Shutters and Splayed Wall.

Where lace curtains or draperies are not considered necessary, the shutters may be arranged to fold back against a pocket in the face of the wall, as shown in Figs. 454 and 455. There are also numerous other arrangements that may be provided for shutters, but those illustrated appear to the author to be the best. The shutters themselves should be framed and paneled with rails and stiles 1⅛ inches thick, although these are made, sometimes, ⅞ or 1$\frac{1}{16}$

inches thick. They should be divided into at least two sections in height, as in Fig. 452, so that either the upper or lower half of the

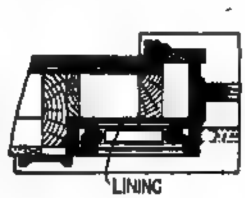


Fig. 453. Plan of Detail shown in Fig. 452.

Fig. 454. Plan Showing Inside Shutters Folding into Recess in Masonry Wall.

Fig. 455. Plan Showing Inside Shutters Folding into Recess in Frame Wall.

window may be closed at will. When the window is more than 6 feet high it is desirable to have three or four sections. Each section is also made in folds or leaves, of which there are usually four to windows 3 feet or less in width, and six for wider windows.* The outer or hanging fold should always have solid panels, but the inner folds, especially in the upper section, are usually fitted with rolling slats. In the best blinds the rolling slats do not have a rod in front, but are fitted with metal bars at the ends, which cause them to work better and take up no space. Fig. 458 shows the stand-

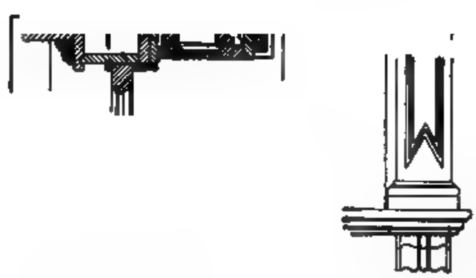


Fig. 456. Window-Finish Brought Forward into Room to Form Pocket for Inside Shutters.

* A fixed rule with certain manufacturers is that the minimum width of any fold shall be 6 inches and the maximum width 12 inches; the most desirable width seems to be between 8 and 9 inches.

ard section, one-half full size, of stiles and panels as made by the Willer Manufacturing Company, Milwaukee, Wis. The folds should be hung so as to fold back in the manner indicated in the drawings. For a description of the hardware trimmings, see Chapter VI. Shutters are usually made of the same wood as the finish of the room, although occasionally a different kind of wood is used. Better shutters will generally be obtained by purchasing them from firms that make a specialty of their manufacture.

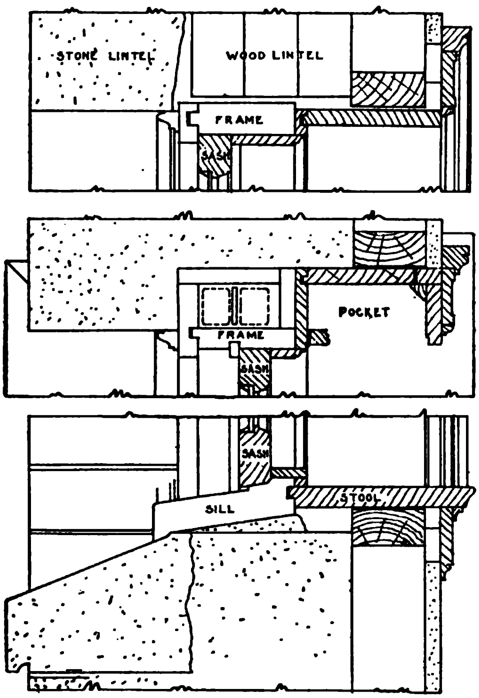


Fig. 457. Finish for Double-Hung Sashes and Folding Shutters. Heavy Furring.

276. SLIDING BLINDS. Besides the folding shutters described in the preceding section, there are three other styles of inside window-blinds, namely, sliding blinds, rolling blinds and Venetian blinds, which are more or less used in place of shutters or cloth shades, and with which the architect should be familiar.

Sliding blinds, although not used as much as formerly, are still

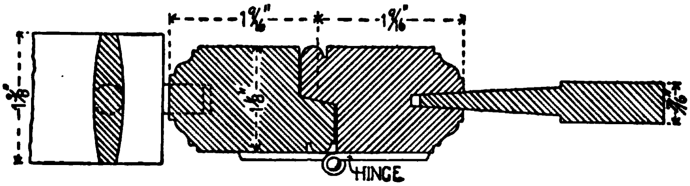


Fig. 458. Stiles and Panel of Rolling-Slat Blind. One-Half Full Size.

made and installed in buildings. They are made in vertical sections to slide up and down between the jambs of the window in the same way as the sashes. The blinds may operate within the height

of the window, or they may run into a bottom pocket, or into a top pocket, or into both a top and a bottom pocket, so that the window can at any time be either wholly or partly uncovered by the blinds. The different sections operate independently of each other, each sliding by the others, so that any section may be raised or lowered without uncovering the other portions of the window. The sections may be balanced by weights or held in place by springs only, that press against the guides or runways. For narrow windows the springs answer very well, but when the blinds are more than 3½ feet wide it is much better to balance them by weights, and balanced blinds will probably give better satisfaction even in narrower windows. Springs are used also in conjunction with the weights for the purpose of holding them sufficiently tight to prevent rattling.

The number of sections to be used in any given window will depend upon the height of the window and the amount of money that can be expended, the cost increasing with the number of sections. For windows between 5 and 7½ feet in height three sections are recommended, and for windows over 7½ feet in height, four sections. The total height of the sections should be such that the entire window between the sill and head may be closed, and the sections lap over each other from ¾ of an inch to 2 inches, according to the size of the window. Each section should be divided into a number of divisions or panels, which should be between 6 and 10 inches in width, including stiles and mullions. These divisions may be filled with panels or slats in any arrangement desired.

To use sliding blinds to the best advantage and without sacrificing the appearance of the window, the window-frames or inside finish should be made to accommodate the kind of blind selected. Special arrangements are necessary for the runways, and in fine dwellings pockets should be provided to receive the blinds when not in use. When the wall is thick enough the best appearance will usually be obtained by having a hinged stool and a panel-back between the casings and allowing the latter to form the front of the pocket for the blinds.

In chambers, schoolrooms, offices, etc., the pocket may be dispensed with, as by using three sections two-thirds of the window can be uncovered, which is usually sufficient, and the appearance of the blinds is not in such places objectionable. The usual thickness of sliding blinds is ⅝ of an inch and the parts are put together with mortise-and-tenon joints. The sections slide in the channels or grooves of applied guideways which are variously secured to the jambs and subjambs and used with or without the stop-beads accord-

ing to the thickness of the walls and the number of sections in the height of the blinds.

Fig. 459. Hinged Stool and Panel-Back Pocket for Sliding Blinds.

Fig. 459 shows perhaps the best arrangement for inside, sliding blinds of three sections: the sections all slide into a pocket behind the panel-back and a hinged stool is provided to cover the pocket when the window is uncovered. Four sections may be arranged in the same way by providing for an additional groove in the guideway. This detail is applicable to all makes of sliding blinds that are held in place by springs at the sides, although some makes may require a greater space between the grooves in the guideway. Weight-balanced blinds may also be fitted in the same way, but for these the pockets for the weights are generally placed in the guideway.

Fig. 460. Guideway-Details for Three-Section Spring Sliding Blinds.

When sliding blinds are used in frame buildings or in brick buildings with 9-inch walls, it is generally necessary to place the guideway against the pulley-stile, allowing it to take the place of the stop-bead, as shown in Figs. 460, and 461. Fig. 460 shows the detail for 2 by 4-inch studs and three-

section, spring, sliding blinds; and Fig. 461 shows the detail for 2 by 6-inch studs and three-section, weighted, sliding blinds. In 9-inch brick walls, and often in old frame buildings, it will be necessary either to box out the casings or to project the guideway beyond the casings.*

In new buildings the guideways should be put up when the building is being finished, but the blinds themselves may be put in or removed at will. Sliding blinds may be made at any wood-working shop, but for the same amount of money much better blinds, and better trimmings, will be obtained by purchasing of firms making a specialty of this kind of work.

Fig. 461. Guideway-Detail for Three-Section Weighted Sliding Blinds.

277. ROLLING BLINDS. These are made of slats strung on wires or ribbons in such a way that they may be rolled on a coil, which is placed in a pocket above the window-head; they run in a groove at each side of the window which keeps them in position. The slats are so arranged that air and light are admitted and the view from within is unobstructed, while they cannot be seen through from without. They are made of various woods to match the standing finish.

Rolling blinds do not require as deep a recess for the window as sliding blinds or shutters, but in frame walls with less than 8-inch studding it will be necessary to box out for the coil either inside or outside of the window. In connection with the rolling blind a single section of sliding blind fitted with movable slats is sometimes used at the bottom of the window; a pocket is constructed behind the panel-back to receive it. With this arrangement the rolling portion need not be so long and the size of the coil is reduced.

Fig. 462 shows a section through the jamb, head and sill of a window in a 12-inch brick wall, fitted with Wilson's Rolling Venetian Blind, with the coil placed in a pocket behind the stone lintel, and a sliding-section at the bottom. When it is not practicable to place the coil in the wall it may be enclosed in an inside cornice placed above the window.† The diameter of the coil, *D*, with the blinds rolled up, is 7 inches for a 5-foot blind; 7½ inches for a 6-foot blind, and 8½ inches for a 7-foot blind.

Provision should be made for easily removing the casing in front of the coil in order to oil the bearings. If the whole front of the box be put up

* Excellent details showing the construction of the guideways and finish for a great variety of arrangements will be found in the large catalogue of the Willer Manufacturing Company, Milwaukee, Wis., and further data concerning construction, in the catalogue of the Burlington Venetian Blind Company, Burlington, Vt.

† Details and descriptions of various arrangements for enclosing the coils will be found in the catalogue of the James G. Wilson Manufacturing Company, New York City.

with screws the coil may be set in place after the finishing is done and may be removed at any time. By framing the rails of the top panel (Fig. 462) into the corner-blocks and putting the latter up with screws, the whole front of the pocket may be readily removed, while the joint will not be perceptible when the finish is in place.

Fig. 462. Detail for Rolling Blinds.

Rolling blinds have been very extensively used in very fine residences and are preferred by many to other styles of blinds. To secure the best results, however, they should be arranged for when the building is constructed.

Rolling blinds may also be fitted to work outside the sashes and may be made of steel as a protection from fire and burglars.

278. ROLLING OR COILING PARTITIONS. It is very often desirable so to unite two rooms by a large opening as to make practically one room of the two, or to divide a given space by means of movable partitions so as to form several separate rooms or one large one at will. To close these large openings coiling partitions or flexible doors have proved as a rule to be the most practicable device, and the architect should, therefore, know the manner in which these coiling partitions operate, the best method of providing for them, and their limitations.

Coiling partitions operate in two ways: (1) by coiling about a horizontal shaft placed above the opening, and (2) by coiling about a vertical shaft placed at the side of the opening. The former will be hereinafter referred to as "horizontal partitions" and the latter as "vertical partitions."

1. *Horizontal Rolling or Coiling Partitions.* The use of these partitions is limited to openings for a single coil of not more than 20 feet in height or 15 feet in width. If the height is over 10 feet it will be better to keep the width down by subdivisions to 8 or 10 feet as the smaller the door or partition, the less will be the force required to operate it. For churches and schools a height and width of from 10 to 12 feet will, as a rule, be found to give the best results.

Fig. 463. Horizontal Rolling Partition.

Where a width greater than 14 feet is desired, the opening may be divided by permanent posts, or by guideways put up so that they can be readily removed when the partition is raised. At the

sides, horizontal coiling partitions require only a grooved guide-way about 3 inches wide, but at the top a box of considerable size is required to enclose the coil.

Fig. 464. Horizontal Rolling Partition.

The best method of putting up the partition will depend somewhat upon the structural conditions of the building. Where there is but a single opening in a 6 or 8-inch partition, the method shown in Fig. 463 is the simplest and gives a neat appearance. Brackets for receiving the shaft are screwed to the face of the jamb and the coil is encased by narrow ceiling as shown.

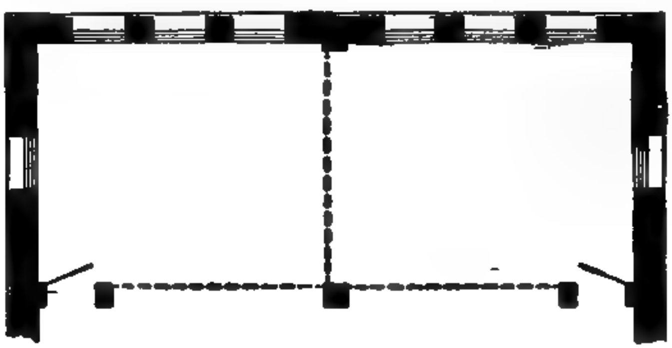


Fig. 465. Rolling Partitions at Right-Angles to Each Other.

If the height will not permit this, the brackets may be set on the face of the partition, the coil being above the opening, as shown in Fig. 464.

When there are several openings side by side, or at right-angles to each other, as in the plan, Fig. 465, it will be better to make the posts forming the

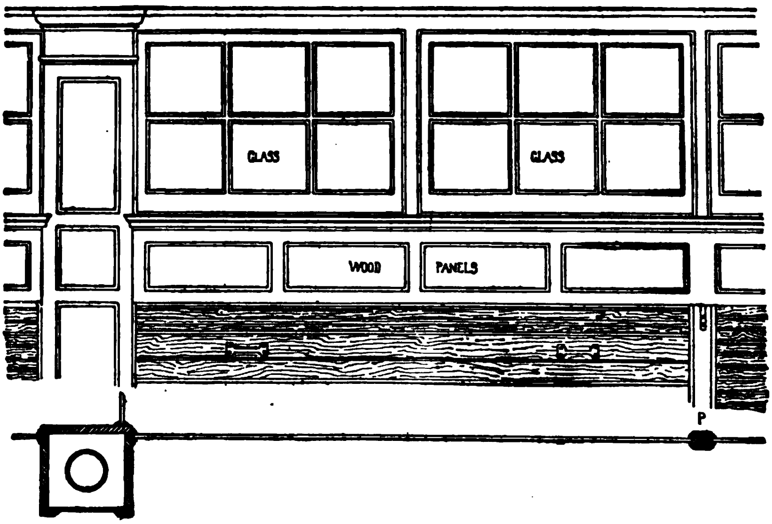


Fig. 466. Casings for Horizontal Rolling Partitions. See Fig. 467 for Details.

permanent partition large enough, for the box containing the coil to go between them. A favorite method for finishing such partitions is shown in Fig. 466, which represents the elevation of a portion of the partition in a room 14 feet high. The casing of the large post is made deep enough to receive the paneled transom enclosing the coil, and transom-sashes are placed above. At *P* is shown a removable post or guideway, which is secured at top and bottom by flush bolts so that it may be quickly removed when the coiling partitions or doors are raised. Where such removable posts are used, it is necessary to place a plank or iron bracket in the coil-box directly over the post to receive the end of the shafts on either side. This block or bearing may be hung from the ceiling by iron bars enclosed in the division between the transom-sashes, and where the transom is over 8 feet long it should be supported in the same way. Removable posts may also be used when the coil is placed and enclosed, as in Figs. 463 and 464; a bracket is placed directly over the removable post.

Fig. 467 shows a cross-section of the transom and coil, shown in Fig. 466. One side of the box or transom enclosing the coil should be put up with round-headed screws so as to be removable at will.

The Wilson partition * works very satisfactorily for openings within the limits previously given. It is composed of wood slats 1½ to 2 inches wide and ½ to ¾ of an inch thick, fitted together with rule-joints edge to edge, and threaded upon tempered-steel bands which run from top to bottom,

* Made by the James G. Wilson Manufacturing Company, New York City.

about 16 inches apart. These bands are riveted to the top bar of the partition, and each band is attached separately to a spiral-spring anchor concealed in the bottom rail and fitted with simple means of adjustment for regulating the tension. This tension on the steel bands holds all the slats in close contact and also permits of the extension of the steel bands as the partition is coiled on the shaft. The partition is hung upon powerful spring rollers which exactly counterbalance the weight, so that the partition may be coiled with comparative ease and will stay wherever put. One side of the partition may be prepared with a flat smooth surface for blackboard use or decorative purposes if desired.

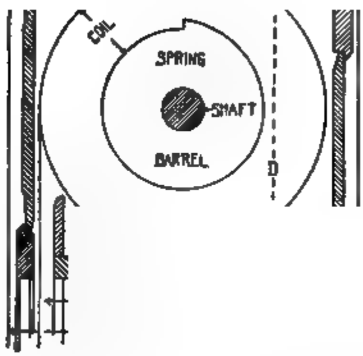


Fig. 467. Vertical Section Through Transom and Coil-Box of Horizontal Rolling Partition Shown in Fig. 466.

For the Wilson partitions, ½-inch thick, the following spaces are required inside the coil-box (*DD* in Fig. 467) to permit of coiling, the actual diameter of the coil being ½ of an inch less:

Height of opening.	Width *D* for partitions up to 10 feet wide.
6 feet	13 inches.
7 feet	14 "
8 feet to 9 feet	14½ "
9 feet to 11 feet	14½ "
12 feet to 13 feet	15½ "
14 feet to 15 feet	16 inches.
16 feet	17 "
18 feet	20 "
19 feet to 25 feet	22 "

The Wilson partitions in whitewood, ½-inch thick, varnished, are listed at 53 cents per square foot, and in quartered oak, varnished, at 65 cents per square foot for openings containing over 35 square feet and not more than 20 feet high, all partitions being measured 1 foot above the sight-opening, or to the top of box in which they coil. Prices include necessary grooves, shaft-rollers and iron handles. Iron brackets, Fig. 464, cost $3.00 a pair; there are special iron brackets to go over movable posts.

Figs. 468 and 469 show the construction of another type of horizontal coiling partitions.* The slats composing the curtain are 1½ inches in total width and are made in two thicknesses, ½ and ¾ of an inch, of various woods and with the surfaces longitudinally ribbed or plain. They are strung upon phosphor-bronze ribbons, spaced 24 inches on centers. Fig. 468 gives an elevation, part of which is omitted to show the shafting, etc., and a vertical

* Made by The Kinnear Manufacturing Company, Columbus, Ohio.

section, which indicates the general constructional details. Fig. 469 illustrates the method of assembling. The peculiar shape of the section removed for the passage of the ribbon permits the joint to move radially without

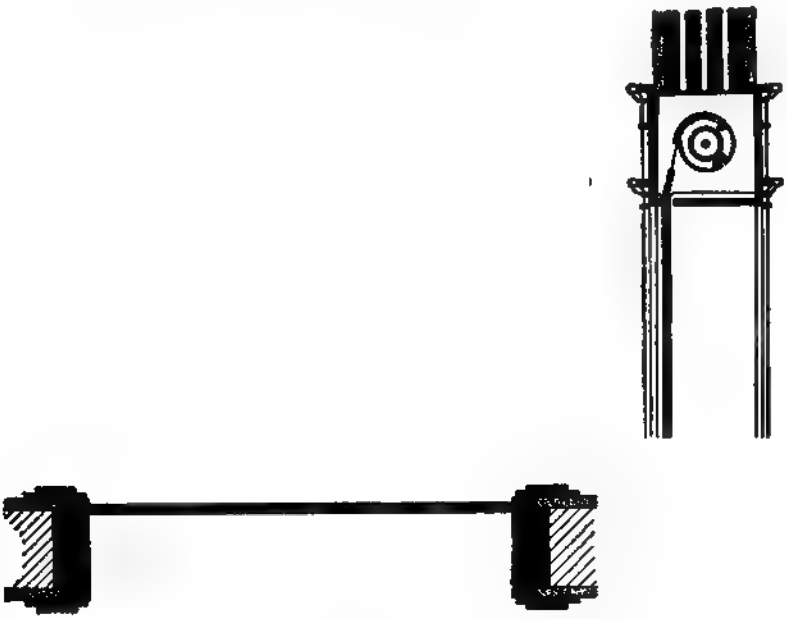


Fig. 468. Kinnear Horizontal Coiling Partition.

abruptly bending the ribbon or causing any change in its relative length or in the length of the curtain during the flexure. Compensating springs in the bottom rail are, therefore, unnecessary and a narrower rail is used with a correspondingly smaller extension into the opening. The curtain is hung upon spiral rings mounted on a tubular-steel barrel, which contains helical steel springs for counterbalancing the weight. The barrel is journaled on shafting in cast-iron supporting brackets. Adjustment of the counterbalance-springs is accomplished by means of a wheel mounted on one of the journals to which the springs are attached. The tension may be increased or decreased according to the direction in which the wheel is turned and the amount of turning. This method is convenient and greatly facilitates the accurate balancing of the curtain. Small partitions are

Fig. 469. Slat-Details. Kinnear Coiling Partitions.

operated by means of a handle placed on the bottom rail. Those of excessively large dimensions are equipped for this purpose with mechanical devices, which usually consist either of a gear and endless chain or of a crank from which power is transmitted to the curtain by means of a shaft and gear.

2. *Vertical Rolling or Coiling Partitions.* These are constructed in the same general way as the horizontal partitions, but the shaft about which the partition coils is placed vertically in a box at the side of the opening. Vertical partitions will close much wider openings than the horizontal partitions will, unless the opening is divided by movable posts. Openings up to 50 feet wide may be closed with two of these doors, one at each side, without difficulty. These partitions, however, cannot be used for openings that exceed 12 feet in height. A clearance-space of only 1 inch above the clear opening is required for the coiling-attachment. Between the coil-boxes, however, the soffit may be boxed down to receive the casing.

Fig. 470. Casing of Coil-Box, Vertical Flexifold Partitions.

For an opening in an 8-inch partition, 6-inch studding, one of the original

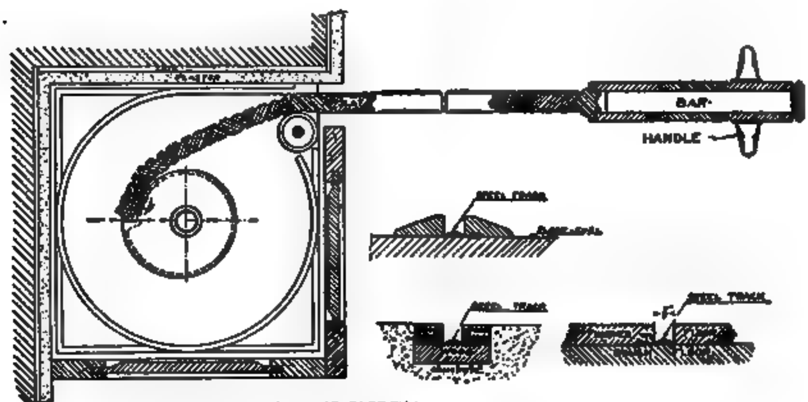


Fig. 471. Paneled Coil-Box for Vertical Rolling Partition.

methods of arranging the coil-box and casing the opening was that shown in Fig. 470, which shows the size of a box for an opening 19 feet wide,

closed by a pair of doors. The portion in solid black indicates the earlier form of the coil-box. Fig. 471 shows the improved form of paneled coil-boxes for the Wilson vertical rolling partitions, and Fig. 472, details of grooves, either below or above the floor-level, for the partition to roll in. Fig. 473 shows a style of casing adapted to openings 10 or 12 feet wide with the trim and doors finished in white enamel.

Fig. 472. Floor-Grooves for Vertical Rolling Partitions.

To save room, the coil-box itself may be paneled and finished at the factory. Coils may be placed at one or both sides of the opening as desired, unless the opening is more than 25 feet wide, when two coils are necessary. The dimensions of the box enclosing vertical rolling partitions depends upon the width of the opening.

The following are the dimensions for *C* and *B*, Fig. 470, for various widths of doors, measured from the box-jamb to the edge of the door when fully drawn out:

For widths of	*C.*	*B.*
8 feet	12½ inches	12½ inches;
9 " 6 inches	14½ "	14½ "
19 "	18½ "	18½ "

The bottom of these doors slides in a hardwood, grooved track, set flush with the floor; the track is furnished with the doors. At the bottom of the track-opening is a steel track, fastened either to the rough flooring or to the hardwood piece set in, as shown in the three small section-drawings in Fig. 471.

The price of flexifold partitions depends on size of doors, kind of wood, finish, and whether opening is to be closed with one door or a pair. For partitions in North Carolina pine, varnish-finish, bronze trimmings, track, etc., all ready to set up, the price is about 70 cents per square foot for the openings between finished jambs. At an extra cost these partitions may be finished in white enamel if desired.

Fig. 473. Vertical Rolling Partition. Casing of Coil-Box.

279. VENETIAN BLINDS.* The common or English type of Venetian blinds, the type first used in the United States and still used for the cheaper makes, consists of a series of thin wooden slats from 1½ to 2⅜ inches wide, arranged laterally in woven ladder-tapes, suspended from the top and connected by cords which raise or lower the slats or tilt them as desired. It is practically a window-shade hanging free, but made of wooden slats instead of cloth.

This blind is very extensively used in England and on the continent of Europe, and to a considerable extent in this country. It

Fig. 474. Wilson's Venetian Blinds, Showing Roller.

possesses an advantage over all other types of wooden blinds in that it may be easily fitted to any window, although it can be used to better advantage in windows having subjambs. The admission of light and air is almost perfectly regulated and controlled, as part of the slats may be opened while the others are closed, or the blind may be drawn up so as to uncover the larger

* The editor has been assisted in the collection of data for the revision of this article on "Venetian Blinds" by the James G. Wilson Manufacturing Company, New York, the Willer Manufacturing Company, Milwaukee, Wis., and the Burlington Venetian Blind Company, Burlington, Vt.

portion of the window. When drawn up, a blind 7 feet high will take up a space of from 11 to 12 inches with 2-inch slats, and from 10 to 11 inches with 2½-inch slats.

Venetian blinds are made by several manufacturers in this country. The general appearance, construction and manipulation is much the same in the different makes, the variations being in the method of hanging and applying to the window and in the quality of the materials and workmanship. The ladder-tapes upon which the slats are hung are of linen or cotton, plain or faced with silk; copper or nickel-plated steel; or phosphor-bronze, bright finish or oxidized.

For fixing the blind to the window-finish each manufacturer has a special method. Thus, an early form, the "Victoria" blind, Fig. 475, had a flat head-piece, 2 inches wide, which was screwed to the stop-bead at the top of the window when the latter was 1⅜ inches wide, or to the under side of the head-casing, where there were subjambs. It could also be fastened to the face of the window-casings by small brackets.

Fig. 475. Early-Form "Victoria" (Venetian) Blind.

Most of the later types of Venetian blinds have a "roller," "top rail" or "rocking-bar" at the top, of which one form is shown in Fig. 474. To this roller or bar the cords for raising or tilting the slats are attached. These bars are usually attached only at the ends, which fit into sockets or hangers screwed to the side of the subjambs or to blocks set against the pulley-stiles. They have sockets very much like those used for cloth shades, and can be put up on the top-beads, on the jamb-casings or on the face of the casings. Many of the improved types of modern Venetian blinds are raised and lowered by means of bands of aluminum-bronze concealed behind the supporting ladder-tapes, and coiled upon an operating-roller overhead. This is controlled by a light strap or cord at the side, in a manner which permits the blind to be raised, lowered, or stopped at any desired point, by a mere movement of the hand, no cleats or other fastenings being required.

In the best modern types the old-fashioned method of operating with cords and pulleys is abolished. The blind always hangs upon a true level

and cannot be made to hang awry or be forced by any means into an uneven position. The slats can be opened or closed or held at any angle by a simple device. It is hung upon steel brackets, bronze-plated, and all the working parts are of the most durable construction.

Fig. 476. Venetian-Blind Pocket. Rocking-Bar.

Fig. 477. Venetian - Blind Pocket. Roller.

Fig. 478. Venetian-Blind. Hanging-Detail.

Figs. 476, 477 and 478 show details at window-heads and sections through upper part of Venetian blinds, the first two illustrations showing pockets. In residences where there are subjambs it is well to form an open pocket behind the head-casing, so that the rocking-bar will be concealed and the blinds less exposed when drawn up. In other buildings this is not essential. The width, *W*, varies with different makes of blinds, 3 inches being usually sufficient for 2-inch slats, although a space of 4½ inches is much better, as a narrower space is apt to wear the tapes. In frame buildings and in 9-inch brick walls the method shown in Fig. 478 is believed by the author to be the neatest, unless a pocket is desired. By this method a block *B*, about ⅝ of an inch thick, is screwed to the face of the pulley-stile next to the inner sash, and the stop-beads are cut against it. If the distance from the sash to the edge of the pulley-stile is less than that shown in the drawing, the block may be allowed to project, as shown by the dotted lines, the blind hanging free like a cloth shade; it is not necessary for it to come between the stop-beads. In Figs. 476 and 478 the dimensions of the Willer Venetian Blinds * with 2-inch slats are given, and at *R* the position of the rocking-bar is shown. Fig. 477 shows the roller of the Wilson blinds.

Besides the types mentioned there are sliding Venetian blinds, in which the slats run up and down in grooved runways attached to the jamb-casings. This prevents disturbance by the wind when the sashes are opened. There is also a type in which the blind is balanced by weights, its action in other particulars being practically the same as that of the common types.

There are various forms of Venetian blind and awning combined. Fig. 479 shows an improved type of awning Venetian blind † with an arrange-

* Made by the Willer Manufacturing Company, Milwaukee, Wis.

† Made by the James G. Wilson Manufacturing Company, New York City.

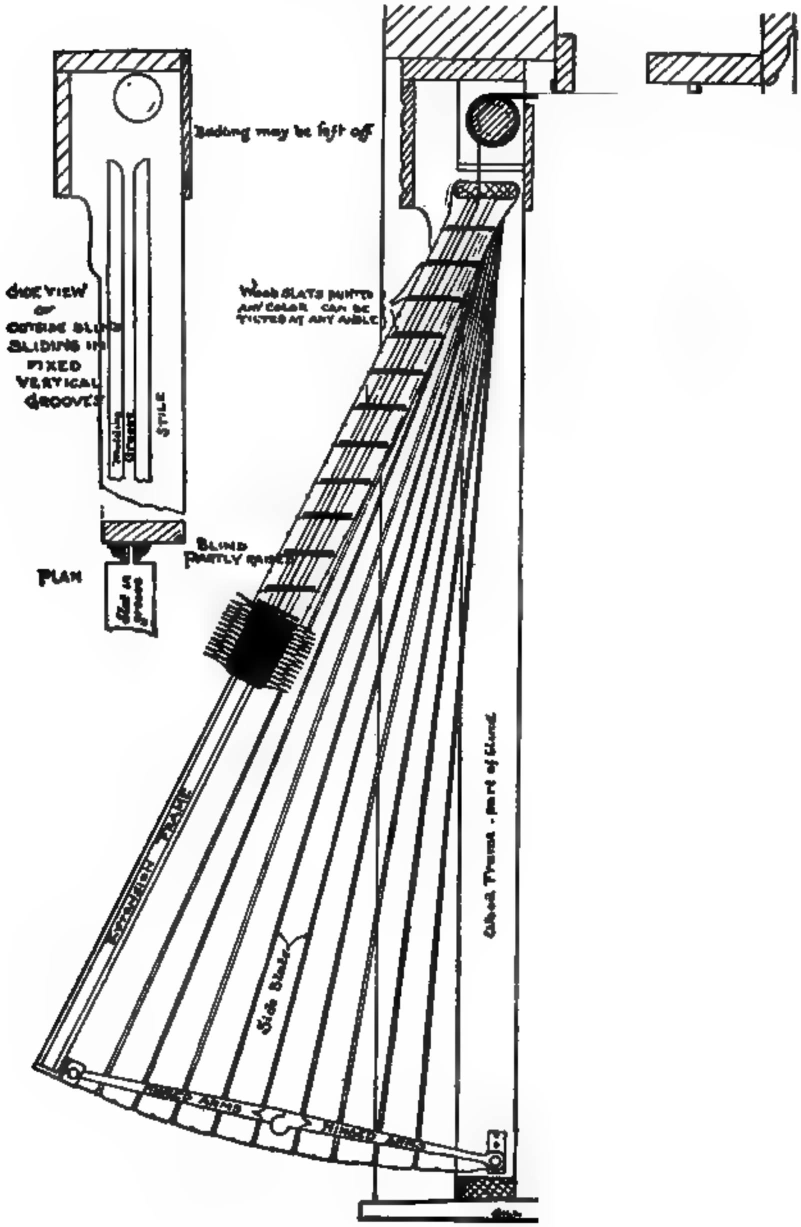


Fig. 479. Wilson's Venetian Awning-Blind.

ment for inside operation. The wood slats can be turned at any angle and slide in grooves either vertically or in the slanting, extension frame. The blind is shown partly raised. The side slats may be omitted.

280. SELECTION OF INSIDE BLINDS. When making a choice of inside blinds for a given building the special advantages of the different kinds and their adaptability to the depth of the window and the character of the room should be carefully considered, and also the preference of the owner. For controlling the admission of light and air, there does not seem to be much choice between the sliding blind with movable slats and the Venetian blind, both of which are superior in these respects to shutters. On the other hand shutters afford a better protection from cold, and with thick walls they are susceptible of a neater arrangement of the finish and in dwellings, particularly, the appearance of the window from the inside is a very important consideration.

281. COMPARATIVE COST OF INSIDE SHUTTERS AND BLINDS. In regard to the comparative cost of the different types of blinds for a window of average size, any schedule of prices would be misleading owing to the fact that there are so many grades of workmanship and finish and also on account of the uncertainty as to whether the prices given by different manufacturers are all for the same grade and kind of finish.

8. BASES AND WAINSCOTING.

282. BASE-BOARDS, BASES, MOP-BOARDS AND SKIRTINGS. In this country the board usually placed around the walls of rooms just above the floor is more commonly designated as the "base," although the English term "skirting" is used in some localities. When the base is not more than 8 inches wide it is generally made of a single board with the upper edge molded, as at *a*, detail *L*, Fig. 395. When the height of the skirting, including the molding, is more than 8 inches it is better construction to have the molding stuck from a separate piece, as shown at *b*, Fig. 395, and rebated to fit over the top of the base. Bases 10 inches wide, however, are often made in one piece, as in Fig. 480. When the skirting is in more than one piece, the wide

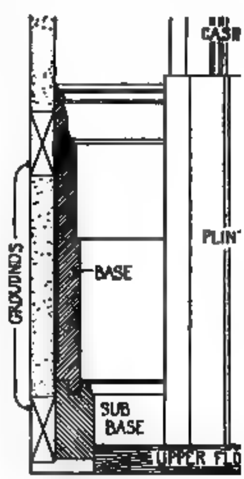


Fig. 480. Deep Base-Board.

part is called the "base" and the top member the "base-molding." Quite often the skirting is made 18 or 20 inches wide so as to form a sort of wainscot. In such cases it should be made in three parts, as shown in Fig. 481, the top member or surbase intersecting with or being coped to the window-stool and apron, if they are the same height from the floor. The dado may be placed either between the grounds, as at *A*, or outside of the plaster, as at *B*. For fine hardwood finish the construction shown at *B* is believed to be the best, the dado being built up with a pine backing keyed on the back and veneered with the finish-wood on the front or face. It should be attached to the grounds only at the top, so that it may shrink or swell without cracking. It is a dangerous proceeding to fasten a wide board both at the top and bottom. If the finish is to be painted, so that the nail-holes may be concealed, the dado may be nailed through the center to the studding or furring. The molding at the top and bottom will hold the edges in position.

Fig. 481. Deep Base, Forming Wainscot.

There are two methods of putting on the base: the first is to put on the base before the overfloor or finished floor is laid, so that, the bottom of the base being ½ an inch below the top of the overfloor, if any shrinkage takes place it will not leave an open joint at the angle. Another method is to keep the bottom of the base about ⅛ an inch above the top of the overfloor and to place a quarter-round or other molding in the angle, as shown at *b*, Fig. 481. This molding, or "carpet-strip" as it is called, should be nailed to the floor and not to the base, in order that the base may shrink or the floor settle, in the shrinkage of the floor timbers, without raising the molding or splitting the base. When there is only a single floor, it is necessary to use the "carpet-strip," as the flooring cannot well be laid against the base. Where there is a double floor the former method is probably the best, although the carpet-strip is often used, especially in the West.

A still better method of construction is that shown in Fig. 480,

where a subbase is used. This method allows the subbase to be put down perfectly straight and thus form a guide for the base. To avoid splitting in case the wood shrinks, the base should be nailed only at the top.

Every room and closet, unless wainscoted, should have a base of some sort.

Sections *m* to *p*, Fig. 486, show various types of skirtings or bases. Section *p* is a poor construction, because it allows the parts to separate with any settling of the floor. Section *o*, also, is a poor construction. Section *n* is an improvement over *p* and *o*. Section *m* shows an excellent construction suggested by Professor C. A. Martin.* A wide ground is put down next the underfloor and the adjoining piece of the base is toe-nailed to the floor. The skirting-piece above is matched into the lower piece and nailed to the ground. After the overfloor is laid, smoothed and filled, the finished subbase is nailed to the floor and back piece. This construction allows floors and subbase to settle without opening the joints. See, also, Fig. 487, detail *G*.

283. DEFINITION, HEIGHTS, AND KINDS OF WAINSCOTING. This term is commonly used to designate a wood or marble lining or covering of the inside walls, whether of paneled work or of plain, matched boarding. The wainscoting may be made any height that is desired, but the commonest height for living-rooms is from 2 feet 8 inches to 3 feet. Halls and bathrooms are often wainscoted to a height of 4 feet or 4 feet 6 inches. Behind the kitchen or pantry sink the wainscoting should be at least 5 feet high to receive the plumbing. Some kinds of wainscoting are especially desirable in kitchens, bath-rooms, back stairways, etc., as a protection to the walls. Paneled wainscoting is usually considered as especially appropriate for front halls, libraries and dining-rooms, and in the principal rooms of most public buildings.

284. PANELED WAINSCOTING. This form may be arranged in almost innumerable ways, but the method of putting together is or always should be, the same. It always should be got out and put together in the shop in lengths as long as can be conveniently handled. Thus one piece will extend from the mantel to the adjoining corner of the room, or will fill the space between two doors or window-trims. When it is possible to do so these sections should be rebated into the finish of the doors, windows, etc., and the angles should be tongued together.

* See "Details of Building Construction," by C. A. Martin. The reader is referred for numerous additional examples of exterior and interior details to this excellent work, from which some of these details have been redrawn or adapted, by permission of the author.

The plan, Fig. 483, shows the way in which this should be done.

The wainscoting is sometimes set outside the plaster, but often the lathing and plastering are omitted back of the wainscoting or the plastering is done between the studs, so that the wainscot shall not have so great a projection. If the wainscot is set outside of the plaster the cap will project two or three inches and necessitate a very heavy door and window-finish. On outside walls, however, whether of brick or frame, the plastering should always be carried to the floor behind the wainscoting. On brick walls the plastering may be applied between the furring-strips, and on frame walls cleats may be nailed to the sides of the studding so that the plaster will be flush with the face of the studs; this, however, involves some additional expense.

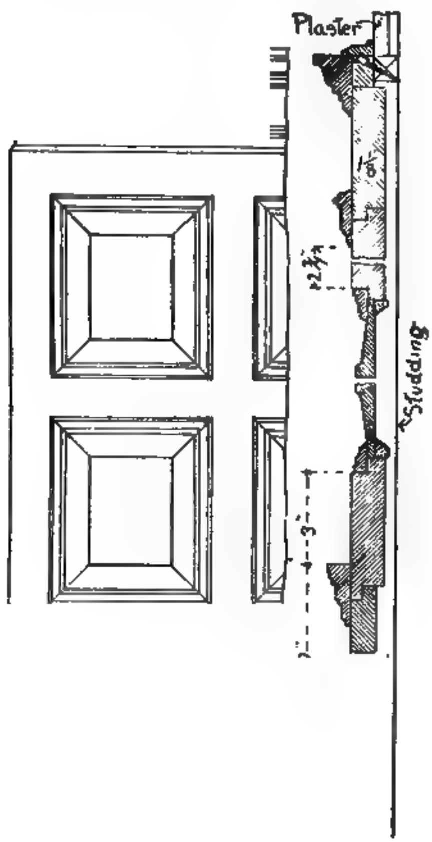


Fig. 482. Elevation and Section of Wainscoting.

Fig. 483. Plan of Wainscoting Shown in Fig. 482.

In the section and plan shown in Figs. 482 and 483 the plastering is stopped by a ground placed just back of the cap. As the wainscoting is glued together and often varnished before it is set up, it is impossible to bend it to fit any irregularities in the walls, and hence it is usual to leave a space of ⅜ of an inch between the back of the paneling and the plaster or studding. The wainscoting should be fastened in place by screws put in from the top and beneath the floor-line or behind the carpet-strip. At the top should be a small, loose molding that can be put on after the paneling is fixed in place and "scribed" to the wall. The usual thickness of the stiles and rails is 1⅛ inches.

Fig. 482 shows a vertical section and part of the elevation of wainscoting, 4 feet 6 inches high, set against studding. This particular wainscot has a neck and a base 15 inches high.

If the wall above the wainscot is to be covered with silk or tapestry a pine slat from ⅛ to ⅜ of an inch thick is nailed to the plaster, as shown at detail *A*, Fig. 482, for the attachment of the silk.

285. DETAILS OF WAINSCOT-PANELING. The ordinary joiner's method of making paneling is shown at *A*, Fig. 484. A groove is worked in the stile, and the molding nailed to both the stile and the panel. If the nail is driven as at *Y*, neither the panel nor the molding can move when shrinkage takes place; consequently the panel cracks. If the nail is driven into the panel and not into the stile the shrinkage of the panel causes an opening to appear between the stile and the molding, unless the molding is "raised" and rebated over the stile. Consequently the paneling should be fastened as shown at *B*. In this construction if the nail goes through the molding into the stile and rail, without penetrating the panel, the panel is loose and can shrink without damage. If glue is used to hold the molding, however, this method becomes as bad as the first.

Fig. 485 shows the cabinet-maker's method, by which an almost perfect piece of work may be secured. In this method a rebate is first cut in the rail on the finish-side. In this the molding is glued solidly so that it becomes practically a part of the rail. When the glue is dry the "varnished" panel is set from the back and held in place by strips nailed to the rail. This leaves the panel loose and free to move should shrinkage take place. All first-class wainscoting should be built in this way.

In very fine cabinet-work the panel-frame would be veneered, as shown in Fig. 485, where *F* represents the mahogany or other choice wood veneer, *D* oak veneer, *E* the core, which may be of ash, pine or chestnut, and *C* and *G* oak veneers of the same thick-

ness as the veneers *F* and *D*, but with the grain of the wood running at right-angles to that of the core and the outer veneers. The core itself is also built up of ⅞-inch strips, glued together.

A B

Fig. 484. Details of Wainscot-Paneling.

Fig. 485. Wainscot-Paneling. Cabinet-Maker's Method.

The veneers used in this class of work do not, as a rule, exceed ⅛ of an inch in thickness.

Fig. 486 shows two other examples of paneled wainscoting, one of matched wainscoting, ten styles of wainscot-paneling and four of skirtings or bases. In the first example of paneled wainscoting the cap is returned on itself against the door-casing. In the second example it is carried around the door-trim on the casing as shown also in Fig. 487, in the two middle drawings, *c* and *d*. Sections *a* to *l*, Fig. 486, show various types of panels suitable for wainscots, doors, or other similar interior finish. The details vary from simple to elaborate forms, some being for flush, plain panels and some for raised moldings and beveled panels. The moldings should never be nailed to the panels, although they frequently are so nailed in poor work, especially when detail *c* is used. In *a*, *b*, *h* and *k* the moldings are run solid on the panel-frames. When panels are more than 12 inches wide they should be veneered in three thicknesses. Sections *m* to *p* show examples of skirtings or bases. See Art. 282.) The first drawing of Fig. 486 shows a matched wainscot. (See, also, Art. 286.)

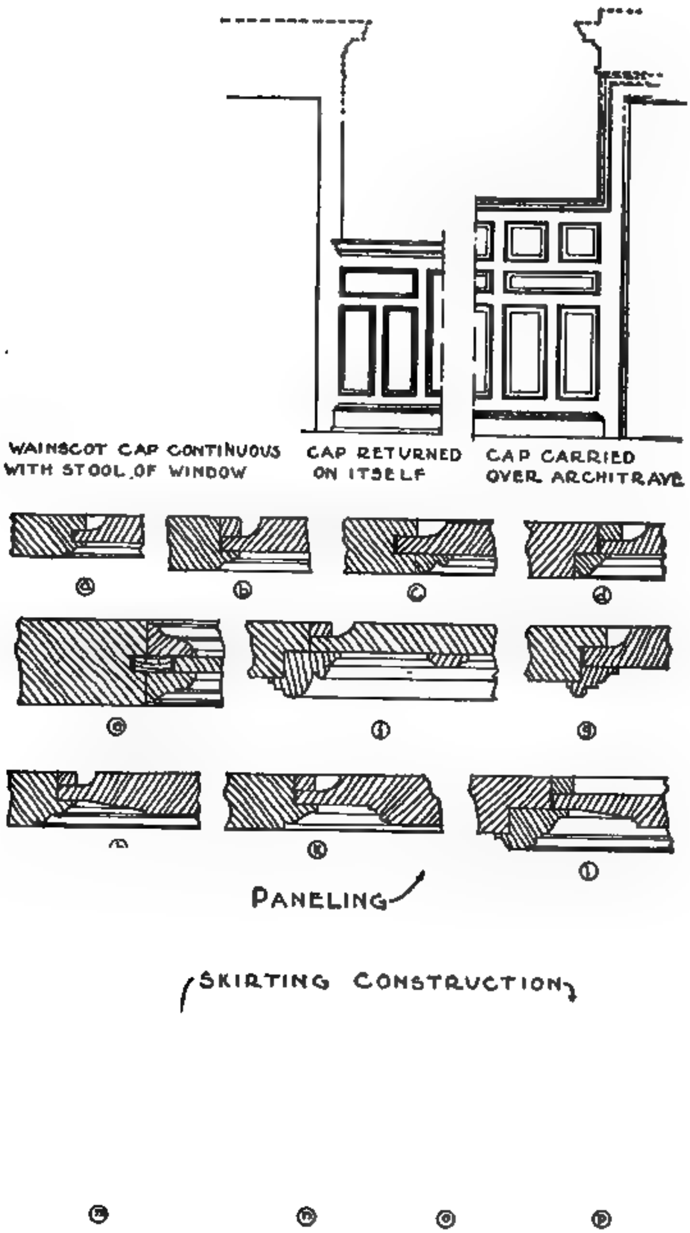


Fig. 486. Wainscots, Paneling and Skirtings or Bases.

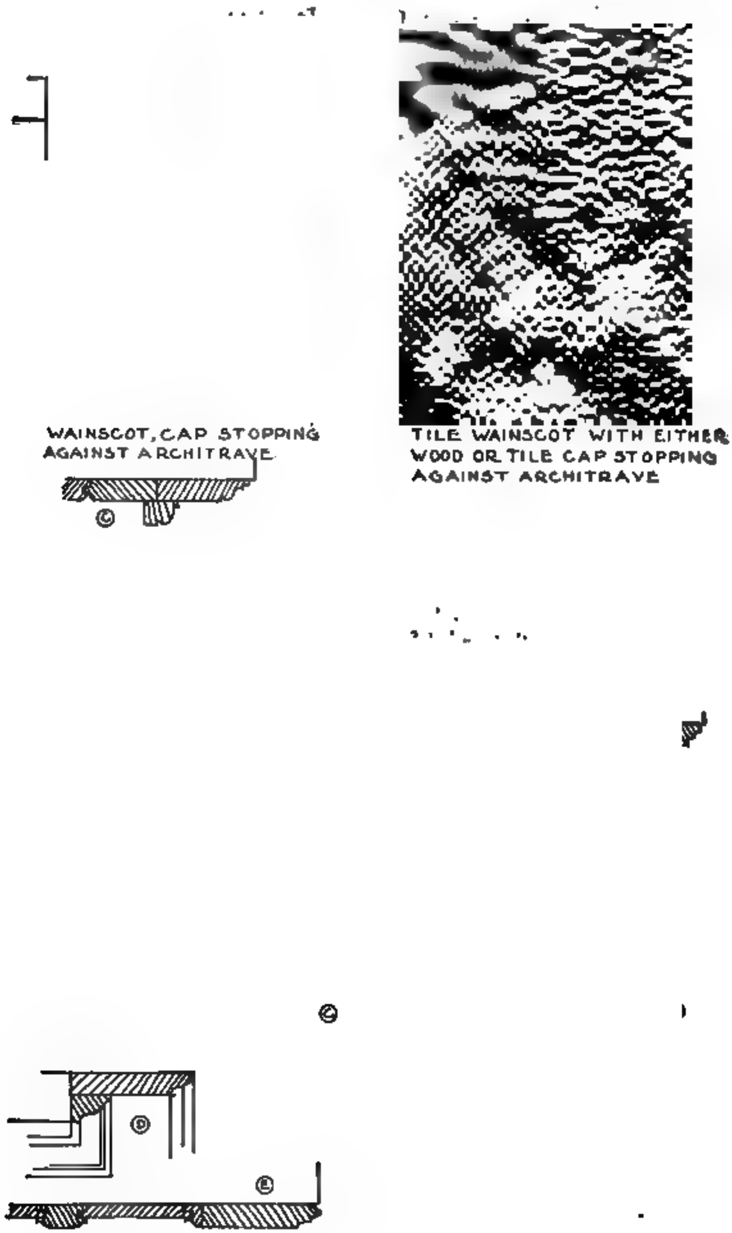


Fig. 487. Matched and Tiled Wainscots and Door and Window-Casings.

Fig. 488 shows two examples of wainscot-caps often used in dining-rooms. The grooves cut into the upper surface are for the purpose of holding plates, plaques, etc. The construction shown at *a* is the better one. Its upper part is made of four pieces of wood glued together before the moldings are cut.

Fig. 489 shows various details of joints for angles of wainscoting and similar interior finish.

Figs. 490 to 499 * show sections and various arrangements of paneled wainscoting in connection with doors, windows, fireplaces and staircases. Fig. 490 shows vertical cross-sections through rails and panels which are fitted together with tenons and grooves. The measurements are given and the adjustment of the 3-inch extra floor-strip outside the base-board is shown. The cap-rail or plate-rail may be put on with or without brackets. If brackets are used the small corner-mold is fitted in between them. The wainscots shown in these illustrations are made in sections in the simple unmolded-panel "craftsman" design, by the company named, and shipped "knocked down," ready to be put in place by the carpenter. They are made on the "unit system" to suit various widths and in heights of from 2 to 6 feet. The wood used is quartered white oak, built up of three-ply stock, cross-banded. As the rails are grooved to engage the edges of the panels and stiles, it is possible to get the size of panel wanted and to adjust the sizes to fit around doors, windows, mantels, etc.

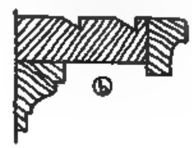


Fig. 488. Dining-Room Wainscot-Caps for Plaques or Plates.

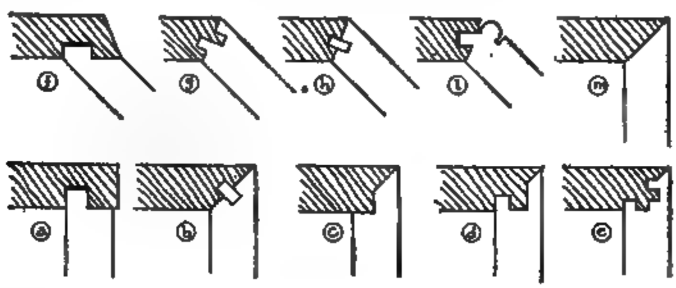


Fig. 489. Details of Angle-Joints for Wainscoting and Similar Finish.

* Courtesy of The Interior Hardwood Company, Jackson City, Tenn.

Fig. 491 shows the use of the 2-foot paneling under a double window; Fig. 492 the wainscot filled around door and window, the 3-foot height being used below the window; Fig. 493 a 3-foot

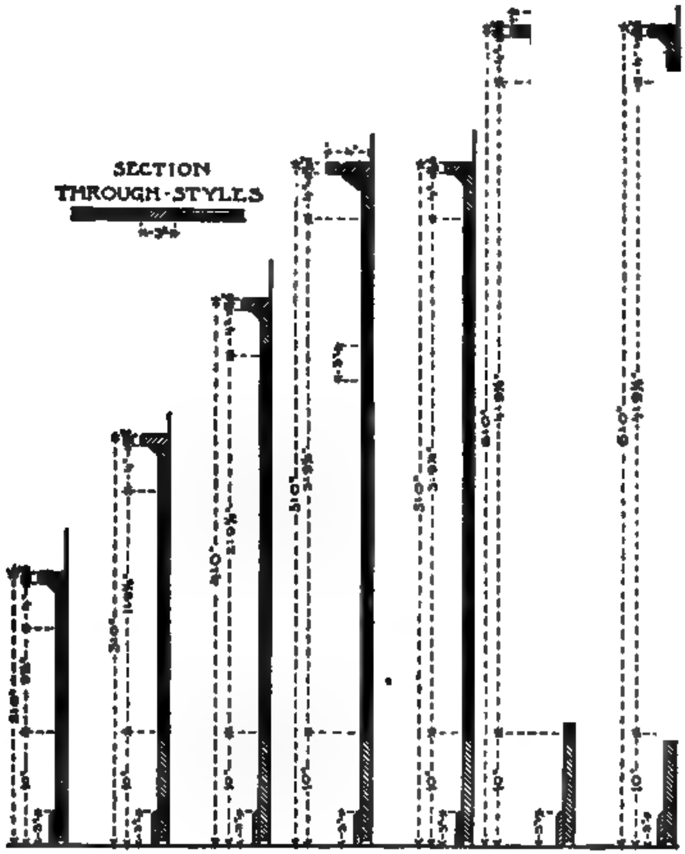


Fig. 490. "Craftsman" Paneled-Wainscot Sections.

wainscot around doors and windows, with the panels placed horizontally under the latter; Fig. 494 a 6-foot wainscot following the slant of a flight of steps by having the base-board fitted to the steps; Fig. 495 a double-paneled wainscot adjoining a fireplace; Fig. 496 the adjustment of a high wainscot to a door flanked by two small, high casement-windows; Fig. 497 a two-paneled wainscot with plate-rail and brackets; Fig. 498 a wide-paneled 2-foot wainscot with a door that has five horizontal panels; and Fig. 499 a perspective of wainscot following runs and landings of a staircase.

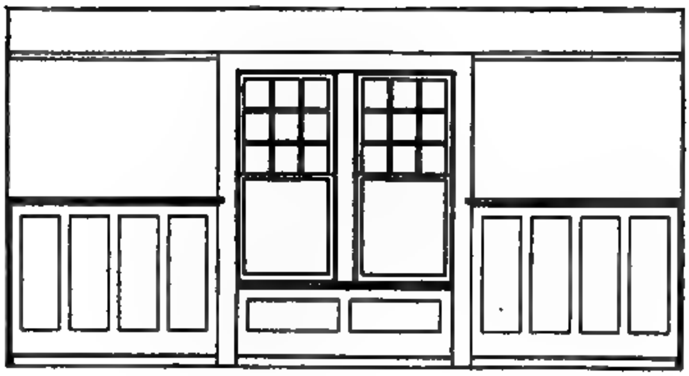


Fig. 491. Paneled Wainscot Around Double Windows.

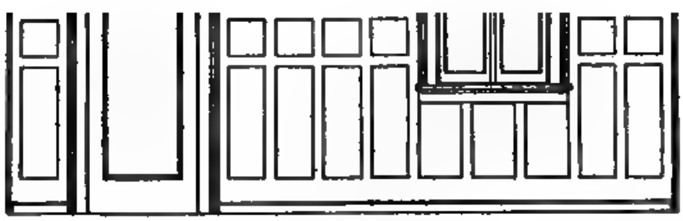


Fig. 492. Paneled Wainscot Around Door and Window.

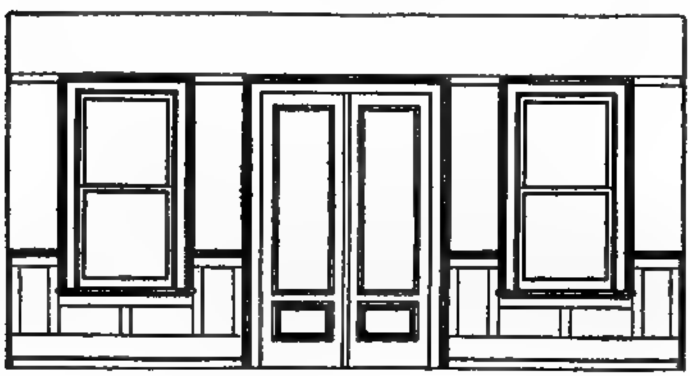


Fig. 493. Paneled Wainscot Around Double Doors and Two Windows.

Fig. 494. Paneled Wainscot Along Steps and Landing.

Fig. 495. Paneled Wainscot Around Fireplace.

Fig. 496. Paneled Wainscot with Door and High Windows.

286. MATCHED WAINSCOTING. In kitchens, back halls, stores, school-rooms, etc., the walls are often wainscoted or "ceiled" with matched boards, which are generally beaded on the

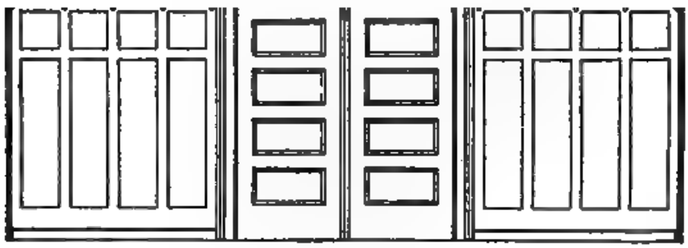


Fig. 497. Paneled Wainscot with Plate-Rail and Brackets.

edge and sometimes in the middle. For good work this "ceiling," * as it is called, should be worked out of 4-inch or 3-inch

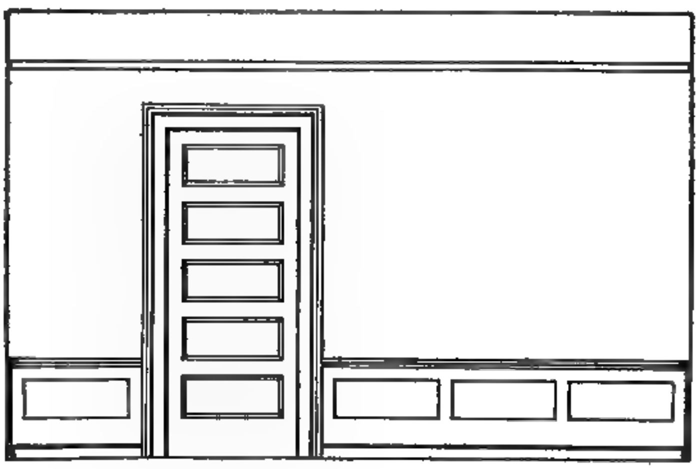


Fig. 498. Wide-Paneled Two-Foot Wainscot.

boards, and should show about 3¼ inches or 2¼ inches on the face. The ceiling is blind-nailed in the same way as matched flooring. It is put up one piece at a time, and generally extends to

* In some of the Eastern States it is called "sheathing."

the floor, without a base. The cap-molding is often rebated to fit over the top of the ceiling. When the walls are to be ceiled in this way, grounds must be put on the studding, if the ceiling is to be set outside the plaster, in order to receive the nails. If the ceiling is set flush with the plaster, bridging must be cut in between the studs for the same purpose.

Fig. 487 shows matched and tile wainscots in connection with

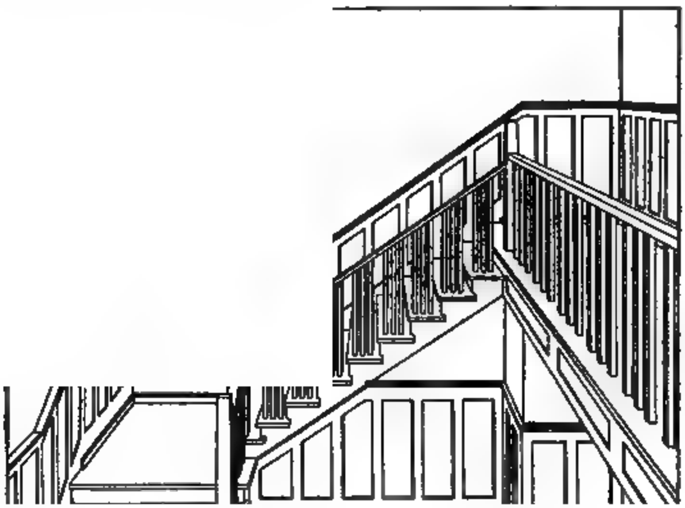


Fig. 499. Paneled Wainscot with Staircase-Steps and Landings.

door and window-casings. Drawing *a* shows the wainscot-cap finishing against the window-casing. The sections *A*, *B* and *C* give details of the construction of the casing above the cap, the cap itself and the casing below the cap respectively. Drawing *c* shows another style of matched, "battened" wainscoting, the cap of which is mitered around the upper part of the window-trim as a back-band. Details *D*, *E*, *F* and *G* show the construction. Drawings *b* and *d* show tile wainscots. The one in *b* has either a wood or a tile cap which finishes against the casings of doors and windows; that in *d* has a wood cap mitering around the openings on the trim. Sections *H*, *I* and *K* show the detailed construction

of wainscot, casing and cap. See, also Fig. 486 for an example of matched wainscoting, which runs across and under a window; the wainscot-cap is a continuation of the window-stool and the casings finish on the cap or stool.

When a finer appearance is desired than beaded wainscoting presents, and paneled work cannot be afforded, molded ceiling or

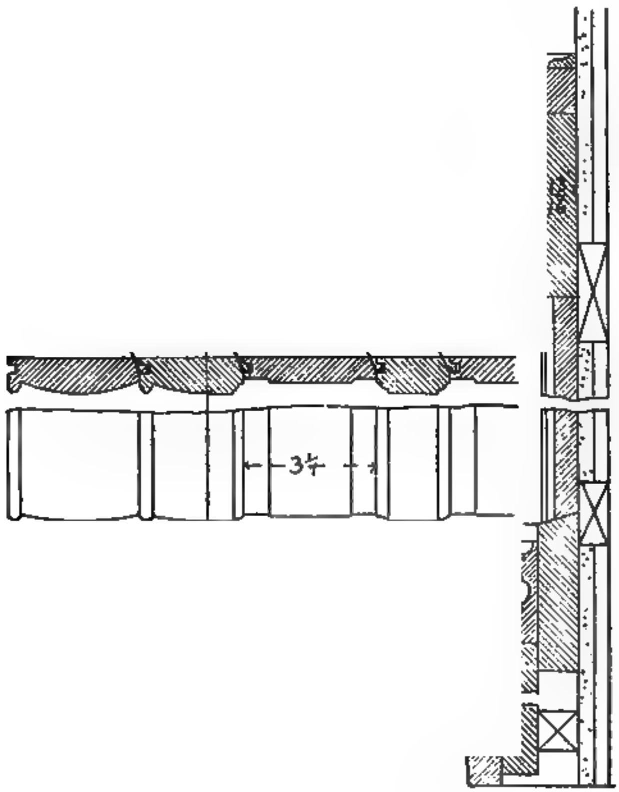


Fig. 500. Molded Wainscot.

sheathing may be used. The ceiling can be molded to any pattern and, if desired, the alternate pieces may be of a different pattern. Fig. 500 shows a section of a molded wainscot and also one with two patterns alternating; the latter arrangement may be so designed as to resemble paneling. When such wainscoting is used with a base-molding it will not do simply to nail the base against the wainscoting, as this would leave spaces between the base and the sunk portions of the molded ceiling and these spaces present a bad appearance and soon fill up with dirt. The proper construc-

tion is to stop the ceiling on a beveled board about ⅛ of an inch thicker than the ceiling and set about ½ an inch above the top of the base, as shown in the section. Above the cap-molding it is good practice to place a small molding that may be fitted to any irregularities in the plastering.

Fig. 501 shows a method of stopping a wainscoting, such as is shown in Fig. 500, at door-openings where only a thin casing is used. In dwellings it is better practice to make the projection of the trim sufficient to stop the moldings of the wainscot, as in Fig. 483, but in large buildings of a semi-public character the small pilaster has a fairly good appearance and is much cheaper. (See, also, Art. 285.)

Fig. 501. Method of Stopping Wainscot on Thin Casing.

9. WOODEN CORNICES, BUILT-UP BEAMS AND COLUMNS.

287. WOODEN CORNICES. Wooden cornices are often used in the principal rooms of dwellings. If they are uncarved they cost about the same as plaster cornices. They should be put up after

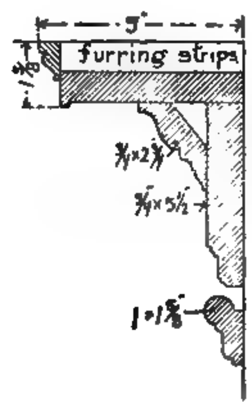


Fig. 502. Wooden Cornice and Picture-Molding.

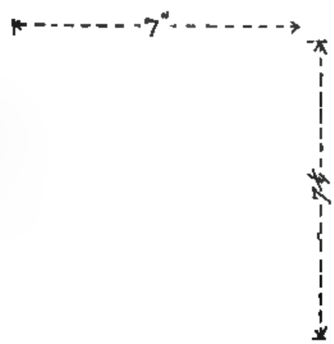


Fig. 503. Wooden Cornice. Classical Type.

the plastering is thoroughly dry. In the best class of work they are glued together in long sections before putting up, and stiffened where necessary by pine blocks glued to the back. To make a good job, grounds should be put on the walls and ceiling before plaster-

ing, at the proper place for nailing the upper and lower members. When the cornice is glued together before putting up, the molding next the ceiling should be left loose to be nailed on after the cornice is set in place.

Figs. 502 and 503 show two different styles of cornices. In the former the picture-molding is placed close under the cornice, of which it apparently forms a part. Attention is called, in Fig. 503, to the way in which the dentils are made. Instead of each being a separate piece, the dentils all form a part of the piece marked *a*; the space between them is cut out. This prevents the dentils from dropping off. (See, also, Arts. 288 and 289.)

288. BUILT-UP WOODEN CEILING-BEAMS. The beams

Fig. 504. Built-Up Ceiling-Beams.

seen on the ceilings of dwellings are not usually solid, as they appear, but are mere shells of thin stuff tongued and grooved together. Around the room is usually placed a half beam or cornice into which the principal beams are framed, and the smaller beams are in turn framed into the principal, as shown in Fig. 504. The side member of the small beams is usually, although not always, continued on the side of the larger beams. When made by cabinet-makers the entire ceiling is often put together on the floor and raised into position against the plaster ceiling, where it is fastened. When put up by joiners most of the work is built in place, the beams themselves usually being glued together in lengths at the shop and put up separately. Whichever way they are put up, the architect should require that grounds be put on the ceiling for securing the beams, as shown in Fig. 504, and for nailing the panel-mold.

As the beams are hollow some method of strengthening them at

the intersections is needed. Cabinet-makers usually set in a pine block the full depth of the beam inside and of sufficient length to be strong enough when mortised out to receive the end of the beam tenoned into it. The end of this latter beam is also strengthened by a similar block on which the tenon is cut.

The outside or show-wood should be mitered where the joint is made. In addition to the blocks placed at the points of intersection, others should be placed at intervals of about 2 feet to give stiffness to the whole structure. The molding surrounding the panels between the beams and that below the wall-beams should be left loose, and set after the beams are in place. The panels may be of plaster or wood. If of the latter they should be put together and finished in the shop, raised to position after the beams are up and the loose molding then nailed in place.

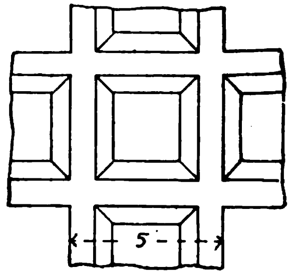


Fig. 505. Detail of Paneling on Under Side of Beams.

When the bottoms of the beams are paneled, as in Fig. 504, pieces should be put in at the ends and intersections of the beams to form the end of the panels, as shown in Fig. 505, which represents a plan of the intersection of the smaller beams.

Sometimes the finished beams enclose solid beams which form a part of the floor-construction, in which case it is generally necessary to build the beams in place. The results are usually better, however, when the ceiling-beams are put together in the shop. (See, also, Arts. 287 and 289.)

289. INTERIOR WOODEN COLUMNS AND ENTABLATURES. Fig. 506 * shows how the column and entablature of one of the classic orders should be put together. An octagonal column is first made by mitering and gluing together the necessary number of planks in such a manner that the center of the column is hollow. If the finish-wood is very expensive the planks are made thin and are glued to a backing of pine or ash which is not quite as well seasoned as the show-wood, and the shrinkage of the backing tends to close the joints in the show-wood more tightly. The angles of the backing, or of the solid planks if no bracing is used, should be splined together, as shown in section *B*. After the shell is glued up it is turned and fluted as if it were a solid timber.

In fluting the shaft, the flutes should be so arranged that the glued

* This cut is taken, by permission, from an article by A. C. Nye, on "Interior Woodwork," published in the "*American Architect*" of October 22, 1892.

joint will come a little to one side of the center of the flutes and not on the arris. "Practice has shown that when the joint is on the arris the thin edges resulting are likely to warp and open the joint. With the joint as shown there is no feather-edge and a firm butt-joint can be made with little possibility of its opening."

Fig. 506. Interior Built-Up Wooden Column and Entablature.

The base is made of octagonal rings glued one on top of the other until the correct size is obtained; it is then turned into shape. The capital is so deeply carved in the example shown that thick pieces of wood are required at the outset, but the hollow space in the center is retained. The shaft of the column should be rebated into cap and base.

In the construction of the entablature a joint is made wherever possible, to diminish the liability to shrink. The frieze, being wide, is veneered and by making the congé at *A* of a separate piece, a considerable saving in material is effected. The dentils are cut from one long strip of wood and, together with the blocks, or half-dentils, between them, form a continuous piece, which is fastened in place like any other molding. The cyma at the top of the cornice is cut from a thick piece of wood, molded "on the flat" and stiffened by blocks of wood glued to the back at intervals of about 2 feet. (See, also, Art. 197, Chapter IV, and Arts. 287 and 288 in this chapter.)

10. MISCELLANEOUS INTERIOR WOODEN FINISH.

290. BLACKBOARDS. In school-rooms fitted with blackboards the top of the wainscot is usually fitted with a shelf to receive the chalk and erasers. Two details of such a shelf are shown in Figs. 507 and 508. Fig. 507 also shows the manner in which slate blackboards should be fastened walls.

CHAIR-RAILS. Often in dining- and sometimes in halls that are not oted, a molding 4 or 5 inches wide is , around the room at the proper height, 3 feet 2 inches to its center, to receive ps of chairs. This molding is called -rail. It may be worked from a single or be built up of two or more members, : designer should always consider how stop against the door-trim and window-

PICTURE-MOLDINGS. It is now

Fig. 507. Detail for Placing of Slate Blackboards.

Fig. 508. Detail of Chalk-Shelf.

customary to specify that a picture-molding be put around all rooms in which pictures are likely to be hung, and moldings for this purpose are carried in stock by the larger lumber-dealers. The common pattern is shown at *A*, Fig. 509. In the better class of work the picture-molding is generally designed to correspond with the

A B C

Fig. 509. Picture-Moldings. Full Size.

other finish, but should be of a section that the ordinary picture-hooks will fit. At *B* and *C*, Fig. 509, two sections are given as suggestions to the draughtsman. The molding should be of the same wood as the standing finish, unless it is to be made a part of the wall-decoration. (See, also, Art. 287.)

Fig. 510. Angle-Bead.

293. ANGLE-BEADS. When projecting angles have a plaster arris or edge it is customary to protect the angle by a turned bead, with a quarter cut out to fit over the plaster, as shown in Fig. 510. Angle-beads are usually made of the same wood as the standing finish, from 1¼ to 1¾ inches in diameter and about 4 feet 6 inches long. Sometimes flat moldings, similar to an ogee stop, are nailed on each side of the angle. These afford better protection for the corner but the turned bead is generally used in residences. Angle-beads can hardly be considered an ornament to a room, and the author much prefers the use of ornamental corner-beads which render the angle-bead unnecessary. (See Arts. 231 and 232.)

11. STAIRS.

294. METHODS OF STAIR-CONSTRUCTION AND NAMES OF PARTS. It is not necessary for an architect to be able to lay out the actual construction of a flight of stairs or to tell just how the hand-rail is to be worked. He should, however, be familiar with the general methods of constructing stairs, in order

to tell when they are being properly built, and he should also be able to so plan the stairs in the buildings which he designs, that they may be not only ornamental but safe and comfortable as well. He should also be familiar with the various terms used in describing stairs, in order to prepare the proper specification. The terms in general use among stair-builders are as follows: The term "staircase" is applied to the whole set of stairs, including the "landings," etc., leading from one story to another. If several stories are connected by flights of stairs one above the other, the whole series of stairs is included in the term. A "flight" of stairs is the part of a staircase from the floor to a landing, or from one landing to another, or, if there is no landing, from one floor to the next. The "rise" of a stair is the height from the top of one step to the top of the next. The "run" is the horizontal distance from the face of one riser to the face of the next.* The "risers" are the upright boards, *R*, Fig. 511. The "treads" are the horizontal boards *T* which form the "steps." The "nosing" includes the projection of the treads beyond the riser, and a small molding or "cove" is placed in the angle. The "carriages" are the rough timbers which support the treads and risers. They are also sometimes called "strings" or "stringers." The "wall-string" or "base" is the finished board placed against the wall; it corresponds to the base around a room. The "outside string" is the finished board on the outside edge of the stairs. The "newel" is the main post where the stairs begin; it is generally larger and more highly ornamented than the other posts. "Angle-posts" are the posts used at the angles of a staircase or well. "Winders" are the steps which come in the angle of a flight of stairs, as *W W*, Figs. 515 and 517.

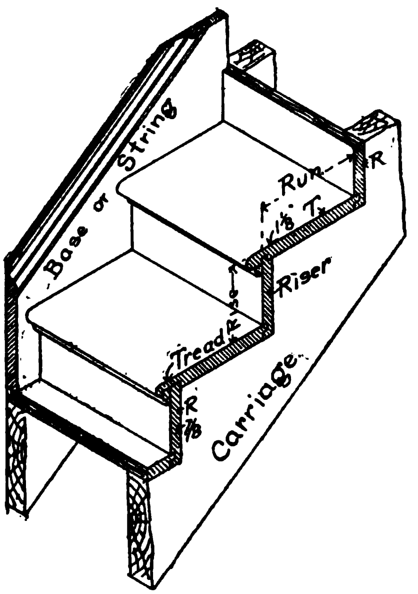


Fig. 511. Stair-Construction Details.

295. LAYING OUT OR PLANNING STAIRS. *General*

* The terms "rise" and "run" are often used to designate the total rise or run of the stairs and not of the individual step; but, as they are much more useful terms when used as here defined, they will hereinafter be used with these meanings.

Requirements and Details. In planning the stairs the architect must be governed to a great extent by the conditions imposed by the plan and arrangement of the building. The first point to be considered is the number of risers to be used and then the width of the treads and the general arrangement of the stairs.

The rise of the stair should never be greater than 8 inches, and that only in inferior stairs. For "grand" staircases a rise of but 5½ or 6 inches is often employed, but to the average American this height is almost, if not quite, as tiresome as an 8-inch rise. For ordinary use a rise of from 7 to 7½ inches makes a very comfortable stair. In schools and other buildings where the stairs are used largely by children the rise should be about 6 inches. The width of the run should be determined by the height of the rise; the less the rise the greater should be the run, and *vice versa.* A safe rule for this proportion is to make the sum of the rise and run equal to 17 or 17½ inches.* Thus a 7-inch rise should have a 10 or 10½-inch run and a 7½-inch rise a 9½ or 10-inch run. The actual width of the tread will of course exceed the run by the projection of the nosing, which should be about 1½ inches. This rule applies only to steps with nosings. When there is no nosing, as is commonly the case with stone steps, the tread should be wider, seldom less than 12 inches.

The number of risers that will be required is determined by dividing the distance between the floor-levels by the rise. It is seldom that the quotient will be without a fraction, and, as the risers should all be of the same height, it will be necessary to vary the assumed rise to conform to the number of risers adopted. Thus, supposing the distance between the top of the floors of the first and second stories of a building is 10 feet 9 inches and we wish to use a rise of about 7½ inches. This rise is contained in 10 feet 9 inches (129 inches) 17⅕ times, so that we must use either 17 or 18 risers. The former would give a rise of $7\frac{10}{17}$ inches and the latter a rise of 7⅙ inches. The run of the stair should be made either 10 or 10½ inches. In figuring the stairs on the plan the number of risers only should be given, leaving the stair-builder to work out the rise from the actual height taken from the building, as this is apt to vary slightly from the height figured on the plans.

* Another very good rule is that the product of the rise and run shall not be less than 70 nor more than 75. Still another rule, given the author by an experienced stair-builder, is that the sum of two risers and a tread shall be not less than 24 nor more than 25 inches. The following examples will illustrate the rules:

1. Rise + Run = 17" to 17½"; or 7½ + 10" = 17½".
2. Rise × Run = 70" to 75"; or, 7½" × 10" = 75".
3. (Rise × 2) + Run = 24" to 25"; or, (7½ × 2)" + 10" = 25."

Besides the number of risers, the run and the width of the stairs from the wall to the center of the rail should also be figured. For stairs of secondary importance the width may be as little as 2 feet 9 inches, but never less than this. For the principal stairs in moderate-priced dwellings a width of 3 feet does very well, but 3 feet 6 inches is much better.

After the number of risers and the runs have been determined the stairs should be arranged so that the requisite number of steps may be provided in the space available for them. This is often a difficult problem and requires considerable experience in planning for its satisfactory solution.

296. DIFFERENT PLANS FOR STAIRS. 1. *"Straight-Run" Stairs.* The simplest and cheapest method of building the

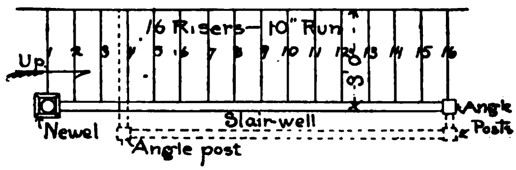


Fig. 512. Plan of Straight-Run Stairs.

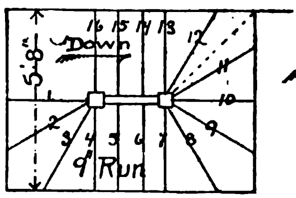


Fig. 513. Plan for Stairs for Limited Space. "Dog-Legged" Stairs.

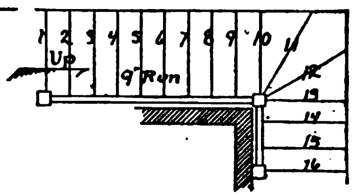


Fig. 514. Plan for Stairs with One Turn.

stairs is to have a straight run, as shown in plan, Fig. 512, the dotted line showing the rail around the landing on the floor above. This frequently requires a longer space than is available, so that it is often necessary, especially in dwellings, to turn the stairs either at right-angles or back on themeslves to get the requisite number of steps into the space at hand.

2. *Stairs for Limited Space.* For back stairways where the space is very limited the arrangement shown in Fig. 513 is generally adopted, as it occupies the minimum amount of space. If the rise does not exceed 7½ inches this makes a comfortable stairway, but when the rise is 8 inches it becomes almost dangerous. Such stairs are very unhandy for carrying up furniture. Builders sometimes put four winders in the angles, as indicated by the dotted line; such an arrangement, however, is really dangerous, and the architect

should never use more than three winders (two risers) in a space less than 3 feet 6 inches square.

3. *Stairs with One Turn.* Fig. 514 shows a very common arrangement both for front and back stairs. When there is sufficient space the winders should be omitted and the straight flights correspondingly lengthened. In cottages, when the front stairs are built in this way, a closet or room often occupies the space usually devoted to the stair-well. With such a plan the partition should be set back so that there will be a space of at least 2 inches between the outside of the rail and the partition, as shown in the figure. If the partition comes directly over the rail it is impossible to make a good finish of the latter, and there is also danger of hitting one's head when ascending the stairs.

4. *"Open-Newel" Stairs.* Fig. 515 shows an improvement over the stair shown in Fig. 513, although of course it occupies more space. The arrangement shown in Fig. 515 is sometimes termed an "open-newel" staircase, while the stairs in Fig. 513 are termed "dog-legged."

5. *"Full-Platform" Stairs.* Fig. 516 shows a full-platform stair, the easiest that can be designed, and if the platform is made wide and fitted with a seat, it makes a very ornamental feature. A staircase having a full platform is also much simpler of construction, that is, if the landing can be supported by partitions, than one with winders, or even with two platforms, and is also much firmer.

The various arrangements of stairs that may be made for ornamental effect in dwellings is almost unlimited, but in most cases they are made up of one or more of the arrangements here shown.

6. *"Circular" or "Geometrical" Stairs.* Previous to 1850 it was the fashion in this country to build circular or geometrical stairs, such as are shown in Figs. 517 and 518, for the principal staircase in the better class of houses. The latter plan is now seldom used, as it is an expensive stair to build and not as easy or effective as the platform-stair, shown in Fig. 516.

When winders must be used the objection to them may be largely overcome by using round corners, as shown in Fig. 517. This makes the stairs much easier and also much more convenient for carrying up furniture. When it is necessary to use winders in public buildings they should wind around a circle of such radius that the width of the treads at the narrow end shall be at least 4 inches, exclusive of the nosing.

7. *Stairs with "Balanced" or "Dancing" Steps.* Although winders are generally drawn as shown in Figs. 513 to 515, the stairbuilder often builds them as shown in Fig. 520, converging not to a common center but to different points. Two or three steps on each

side of the winders are then usually laid in a similar manner. This is a much easier stair than one with ordinary winders. The Eng-

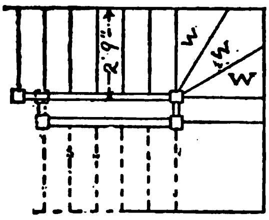


Fig. 515. Plan of Open-Newell Staircase.

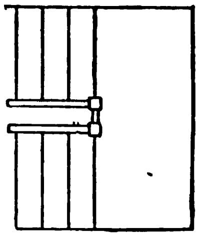


Fig. 516. Partial Plan of Stairs, Showing Full Platform.

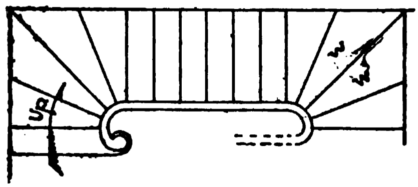


Fig. 517. Round-Cornered or Geometrical Stairs.

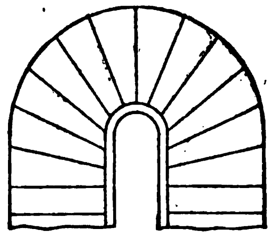


Fig. 519. Circular Stairs with "Balanced" Steps.

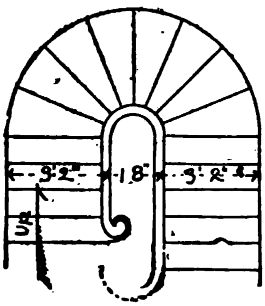


Fig. 518. Plan of Circular or Geometrical Stairs.

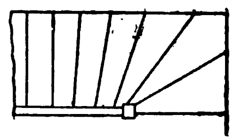


Fig. 520. Stairs with Balanced Winders.

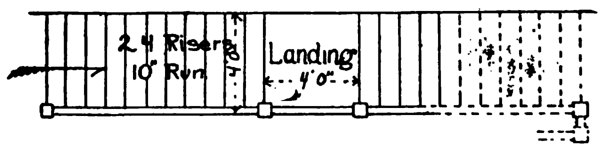


Fig. 521. Stairs with Straight Runs and Platform.

lish term for steps arranged in this way is "balanced" or "dance" steps; there does not appear to be any term for this arrangement in common use among American stair-builders.

In geometrical stairs, such as those shown in Fig. 518, the winding steps have the same rise as the others, but a much narrower tread at the inner end, the inclination of the line of nosings of the winders is much steeper than that of the other steps, and this gives a sudden and ungraceful change to the inclination of the hand-rail. To avoid this and also to give some additional width at the narrow end of the tread the steps are "balanced," as shown in Fig. 519, each riser converging to a different point.

297. HEAD-ROOM FOR STAIRS. The most common fault with stairs, particularly in dwellings, is the lack of sufficient head-room. One should never calculate on less than 6½ feet from the under side of the floor-opening to the top of the tread below, and 7 or 8 feet of head-room is much better. With the ordinary thickness of floors in dwellings the well-room should extend over at least 12 risers when the rise exceeds 7½ inches, and 13 or 14 risers when it is less. Where one flight is built directly above another the vertical distance between the two should not be less than 7 feet 6 inches in the clear, measured over the face of the riser. The architect or draughtsman cannot be too careful in this particular, as expensive and otherwise well-arranged stairways are often greatly marred by cramped head-room.

In planning the stairs for buildings of a public nature the first consideration should be the comfort and safety of the people using them. Every ten or twelve steps, landings should be provided which should be as long as the width of the stair, and winders should be entirely avoided, unless placed on a circle, as previously described. The rise of the stairs in public buildings should not exceed 7 inches. All sudden alterations in the length of flights should be avoided and no flight of less than three risers should be permitted. The use of single or isolated steps in public buildings is dangerous and is prohibited in most of our large cities.

298. WIDTH OF PUBLIC STAIRS. The width of the stairs should be proportioned to the greatest number of people that may possibly have occasion to use them at one time. Most cities having building codes regulate the width, rise and tread of stairs. The law regulating the construction of buildings in the city of New York provides that "stairways serving for the exit of fifty people shall be at least 4 feet wide between railings, or between walls; and for every additional fifty people to be accommodated 6 inches must be added to their width. The width of all stairs shall be measured in the clear between hand-rails.

In no case shall the risers of any stairs exceed 7½ inches in height, nor shall the treads, exclusive of nosings, be less than 10½ inches wide. No circular or winding stairs for the use of the public shall be permitted."

In general the stair shown in Fig. 516 is the best for public buildings, and next to this is the straight stair with a platform between the runs, as in Fig. 521.

Stairs should be well lighted, particularly at their approaches, and in hotels, factories and other buildings of a public nature a skylight should be placed above the stair-well, both for lighting and for ventilation.

299. THE "BOSTON" METHOD OF STAIR-CONSTRUCTION. The foregoing observations apply in the main to all stairs, whether of wood, metal, stone or brick. The construction of the stairs, however, varies with the kind of material used. As this book treats only of wood construction, only the methods of constructing wooden stairs will be described.

In the construction of wooden stairs two distinct methods are employed, the advocates of each claiming that theirs is the best. Each method naturally possesses some advantage over the other; and while in most cases either method will give satisfactory results, there are often particular conditions under which one or the other is the most efficient. As there are no well recognized terms for designating the different methods, it is necessary to describe in the specifications the particular manner in which the stairs are to be built.

By the first method, which might be designated as the "Boston" method, as it is the principal method used in that vicinity, the carriages and other supports for the finished stairs are put up by the stair-builder before the building is lathed, and temporary treads are nailed to the carriages for the convenience of the workmen. The carriages are accurately cut from pine or spruce planks to fit the treads and risers and made to line perfectly true, level and square. As they carry the weight of the stairs and the loads which come upon them the carriages should be fastened in place securely and the timber on which they rest should be of sufficient strength to carry the entire weight of the flight above it. For first-class work the carriages should be spaced 12 inches on centers, and in long flights a false riser should be spiked to

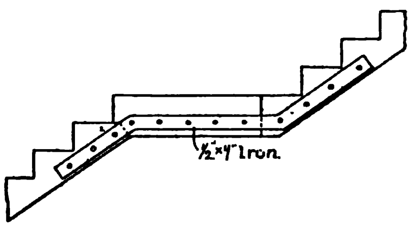


Fig. 522. Construction of Carriage for Stairs Shown in Fig. 521.

the rise of the carriages every four or five steps, as shown in Fig. 533, the step being cut back to allow for the thickness of the board.

When a straight flight of stairs, with a platform like that shown in Fig. 521, is to be built, it is desirable to extend the platform-posts to the floor-timbers below, but if this cannot conveniently be done, and there is no partition under the outer carriage, the carriages may be supported or strengthened at the platform by pieces of flat iron, screwed or bolted to each carriage, as shown in Fig. 522. Stairs for public buildings, factories, etc., however, should invariably have the platform-posts carried down to a solid support.

After the plastering is dry, and while the other interior finish is being put up, the stair-builder puts in place the finished portions of the stairs one piece at a time. The treads and risers are all made or "got out" at the shop, where the under sides of the treads are grooved to receive a tongue worked on the upper edge of the riser and the bottom of the riser is grooved to receive a tongue on the back edge of the tread, as shown in Fig. 523. The risers are first nailed to the carriages, commencing at the top, and the treads are then fitted into the risers, and nailed. The wall-string or base is roughly scribed to the profile of the stairs and the edge cut away at the back to form a tongue, which is then driven into a groove cut in the ends of the treads and risers, as shown in the figure. The nosing is cut off so as to butt against the base. This arrangement permits the base to shrink, without opening the joint at the intersection. Considerable care has to be exercised in cutting the groove for the base to get it at exactly the right distance from the wall-line. In this method no glue or blocking is used for holding the treads, risers or strings, but all parts are secured to the rough work by nails.

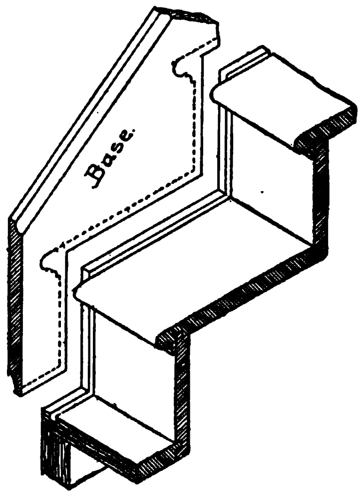


Fig. 523. Joining of Risers, Treads and Wall-String.

The outer face of the stair may be finished as shown either in Fig. 524 or Fig. 525. The former is called an "open string" and the latter a "closed" or "curb-string." The open string in this method of construction is the cheaper.

In "open-string" stairs a plain board, cut to the profile of the stairs and mitered against the ends of the risers, is first nailed to the carriage or blocked out from it so as to cover the plaster, and the nosing is continued across the end of the tread by means of a solid molding worked to the shape of the nosing and mitering with it, as shown in the detail drawing, Fig. 528, the other end of the molding being returned on itself. Before this molding

is fastened in place the balusters are dovetailed into the ends of the treads as shown at *F*.

If the stairs are to be finished with a "closed string" the string in this method of construction is made hollow, as shown in the section, Fig. 526, and the inner part is tongued into the treads and risers in the same way as the wall-string. The outer string is then put up, generally by being

Fig. 524. "Open-String" Stairs.

nailed to furring-blocks, and the top member is next fastened in place to complete the string; the balusters are either mortised into it or simply cut on a bevel and nailed. As the string must be quite wide it is generally paneled to prevent excessive shrinking. Fig. 527 shows another method of capping a curb-string, which the author prefers to that shown in Fig. 526. The piece *B* is cut between the balusters and holds them in place.

Open-string stairs are often ornamented by planting thin brackets of wood on the face of the string before the nosing is put on, as in *C* and *D*,

Fig. 524. They should be mitered with the ends of the risers. In very ornamental work these brackets are usually carved, as shown in Fig. 529. Stairs are sometimes finished as in Fig. 530, by paneling the back and under side of the steps to make them appear solid.

The newel and angle-posts, which are generally built up out of thin stuff, are put up before the strings, and the latter are housed into them. Stair-builders will sometimes try to convince the architect that to secure a strong stair it is necessary to build in the angle-posts when the carriages are up; but if the stair-builder thoroughly understands his work the framework can be as solidly constructed without the posts, which may then be put up with the other finish-work and thus escape being subjected to the dampness invariably produced by the wet plastering. In inferior, pine stairs the posts may be built in with the carriages and boxed to prevent injury.

Fig. 525. "Closed" or "Curb-String" Stairs.

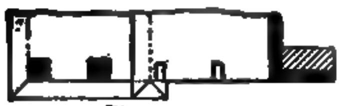
300. THE "ENGLISH" METHOD OF STAIR-CONSTRUCTION. In the second method of construction, which may be called the "English" method,* the finished portion of the stairs is all put together at the shop, carried bodily to the building and set in place on the carriages, which are often made as in Fig. 531.

When built in this way the treads and risers are generally tongued together as before described, except that sometimes the molding under the nosing is also ploughed into the tread, and all glued together. See, also, Fig. 537, sections *a* to *f*. Section *a* shows glued and blocked treads and risers, which are "ploughed" into each other. In the upper drawing the molding is let into the under side of the tread just back of the nosing. Drawings *c* to *f* are horizontal sections through the joining of risers with

* The author is informed that this method is used almost exclusively in California, and to a considerable extent throughout the West.

outside strings in an open-string stair. A simple, mitered joint is shown at *c;* a butt-joint with string-molding planted on, at *d;* a butt-joint with a thin piece for ornament planted on the string and half-mitered to the riser,

Fig. 527. Outer-String Cap of "Closed-String" Stairs.



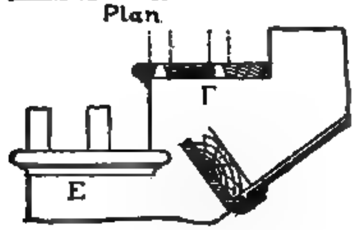


Fig. 526. Section on Line A-A, Fig. 525.

Fig. 528. Outer String, Balusters, Nosing and Cove. "Open-String" Stairs.

at *e;* a thick piece for heavier, carved ornament planted on the string and mitered to the riser, at *f.*

In this English method, however, the connection of the treads and risers with the base (called in this construction the "wall-string"), is made in an entirely different manner from that described in the Boston method; the profile of the stair, including the nosing, is carefully traced on the string, which is then cut out as at *A,* Fig. 532, so that the ends of the treads and risers may be "housed" into it at least ½ an inch and then wedged and glued, as shown at *B.* The treads and

Fig. 529. Decorative Details for "Open-String" Stairs.

risers should also be blocked and glued together, as shown in Fig. 531. The outer string is then put on and glued, and if it is a curb or close string the treads and risers are housed into it, as into the wall-string, a single string 1¾ inches thick often being used in that case. When this method of construction is used the base or wall-string should be at least 1⅛ inches thick, and it is better to put a curb-string on the outside, and work its inside face in the same way as the wall-string. For the inferior stairs in dwellings this makes the cheapest construction and if well housed, blocked and glued, they will have sufficient strength without carriages provided they are not over 3 feet wide and the string on each side is solidly nailed to a partition. It is customary, however, to put 2 by 4-inch joists under such stairs to help support them and also to receive the lathing underneath.

Fig. 530. Paneled "Open-String" Stairs.

When the stairs are put together in the shop the only way in which they can be accurately fitted to the carriages is by wedges driven from below. This obviously cannot be done after the soffit or under side of the stairs is plastered, so that the plastering, if there is any, must be done after the stairs are finished. This is a very serious objection to the English method of construction, as no plastering should ever be done in a building after the finished work is in place, especially if the wood is to be varnished. If the stairs are put up without wedging they are pretty sure to squeak. The author, therefore, in his own practice makes it a rule to specify the Boston method of construction for all but inferior, pine stair-cases, unless the stairs are to be paneled underneath, in which case there will be a better result if the English method of construction is used. Where plastering is necessary after the woodwork is completed, some kind of plaster-board should be used for the ground, and then only a thin, white coat will be required to finish it.

Fig. 531. "English Method" of Stair-Construction.

In stairs of public buildings, the treads, if of wood, should be of oak, longleaf southern yellow (Georgia) pine or Douglas fir (Oregon pine), and never less than 1⅛ inches thick. Treads 1¾ inches thick are often used. When they are more than 1⅛ inches thick, however, it is good practice to groove them on the under side as in Fig. 534 in order to prevent warping.

301. THE "PENNSYLVANIA" METHOD OF STAIR-CONSTRUCTION. There is still another method of stair-building, much used in Pennsylvania, which is a combination of the two methods above described.

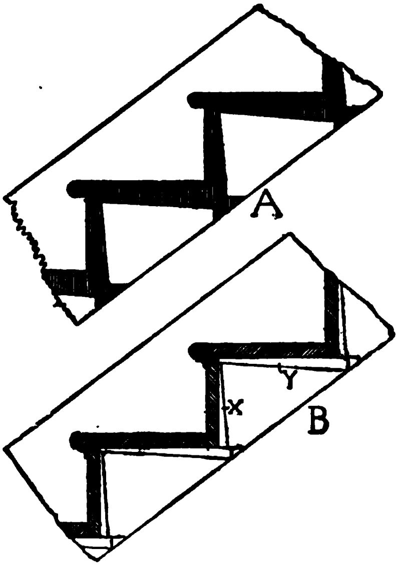


Fig. 532. Connection of "Wall String" to Treads and Risers in "English Method" of Stair-Construction.

In this method the carriages or horses are cut to fit the steps, as shown in Fig. 533, and put up to line perfectly. A 3 by 4 or 3 by 6-inch joist, called the "wall-bearer," is nailed or spiked flat to the wall, about ¾ of an inch below the back edge of the risers. In long flights a false riser is nailed to every fifth or sixth riser of the carriages, the treads being cut back for the purpose, and fastened securely to the wall, with the inner end thrown a little higher than level. This braces and stiffens the work very much. After the plaster is dry the wall-string, which has been previously housed out for the steps as in the English method, is set and nailed to the wall. The risers and treads are then driven into the wall-string, commencing at the bottom, and nailed to the carriages. Wedges are also driven in and glued on top of the wall-bearer to give additional support to the back edge of the steps, as shown in Fig. 534. The inside of the face-string, if it is a curb-string, is then tongued into a groove cut in the treads and risers, as in the Boston method. This method differs from the Boston method only in the putting up of the wall-bearer and string and in having wedges on top of the wall-bearer. In this respect it is probably superior to the first method described.

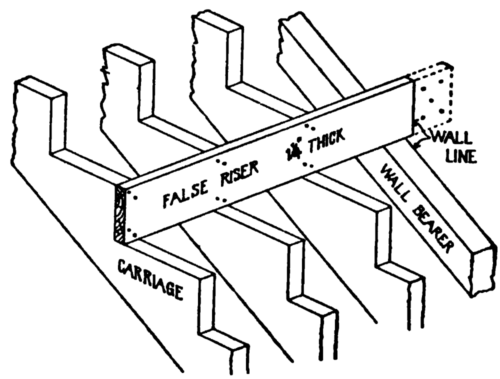


Fig. 533. Stair-Carriages and False Riser, Pennsylvania Method.

For the finest grades of work the material should all be painted on the

back and filled and shellaced on the face before being taken to the building, which should be thoroughly dried out beforehand.

302. NEWEL-POSTS. The stair-posts, if made of hardwood, should be built up out of thin pieces, which are usually blocked and glued at the joints on the inside. Turned posts of hardwood are not usually desirable; when turned from a solid stick they are very apt to check and, when glued up, to open at the glued joints. A newel, such as shown in Fig. 524, should be built up in the same way as the Corinthian column shown in Fig. 506. Angle-posts should be extended below the outside string and should have an ornamental drop at the bottom.

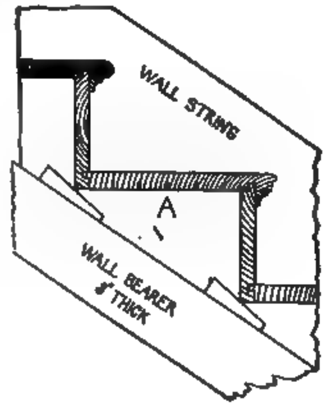


Fig. 534. "Pennsylvania" Method of Stair-Construction.

In the principal staircase, the architect should provide for a half-post where the rail terminates against a wall; otherwise the stair-builder will fasten the rail to a wooden or iron plate screwed to the wall, and this does not make so neat a finish as the half-post.

Fig. 537 shows, in drawings *g* to *k*, four different methods of construction of newel-posts, in *a* to *f*, vertical sections through stair-

A 3⅞x3⅛ B 3¼x3⅛ C 3½x4 D 2¾x3¼

Fig. 535. Sections of Hand-Rails.

treads and risers and in *l* to *p*, sections through five different forms of hand-rails. When newels are built up and square in cross-section they are jointed at the angles in various ways with dowels, splines, tenons, glued blocks, etc., as shown in sections *g* to *k*, Fig. 537.

303. HAND-RAILS. 1. *Rails on Well-Hole Side.* The section of the hand-rail is more a matter of taste than of construction and may be designed to conform to the interior finish. As a rule, however, the section of the rail should contain at least 9 square inches, 3½ by 3½ inches being a very good size. Several good

sections are drawn in Figs. 535 and 537, to a scale one-fourth full size. The section at *D*, Fig. 535, is preferred by many for public buildings, but for residences one of the other sections seems more pleasing and appropriate.

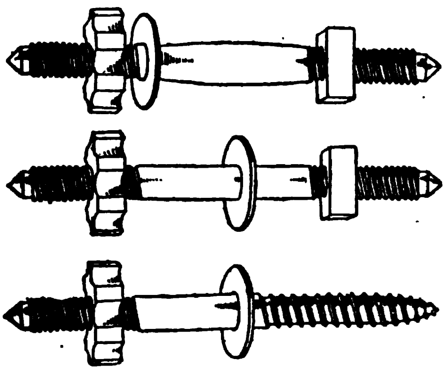


Fig. 536. Hand-Rail Screws or Joint-Bolts.

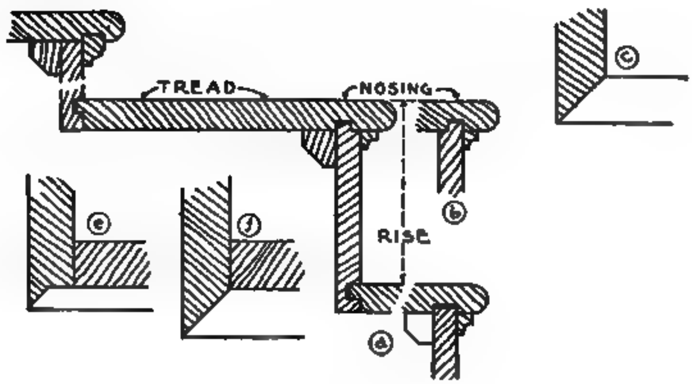
A safe rule for the height of the rail is to make it about 2 feet 6 inches above the tread, on a line with the face of the riser. For grand staircases the height is sometimes reduced to 2 feet 4 inches; but for steep stairs it should never be less than 2 feet 6 inches. The height of the rail should also be increased over winders, especially those of steep pitch.

On landings the height of the rail should be equal to the height of the stair-rail measured at the center of the tread. The usual height in residences is from 2 feet 8 inches to 2 feet 10 inches.

In ordinary stairs the rail is generally straight, and joins the posts at an oblique angle, as in Fig. 525. At the angle-posts the rails, if made straight, will strike the post at different heights on its opposite sides, and to overcome this the rail is often "ramped," as shown in Fig. 524. The ramp is made high enough to bring the ends of the rails to the same level on each side of the post. The lower end of the rail is also often finished with an "easing," in English books termed "knee" or "kneeling," as shown in the same figure. Ramps and easings add much to the appearance of a stair, but they also add to the cost, and the stair-builder cannot be expected to put them in unless they are mentioned in the specifications or shown on the stair-drawings.

2. *Rails on Wall-Side.* Stairs which may be used by large numbers of people should have a rail on the wall-side if the stair is 4 feet wide, and all stairs built between partitions should have at least one wall-rail. These rails are generally made with a round section of about 2¼ inches diameter, and should be fixed to the wall on iron or bronze brackets made for the purpose. The ends of the rails are sometimes left straight, but it is better to return them against the wall.

All end-joints in rails and connections between rails and posts



(g) (h) (i) (k)

(m) (n)
HAND RAILS

(o) (p)

Fig. 537. Stair-Treads and Risers. Newels. Hand-Rails.

should be made by means of joint-bolts or hand-rail screws, of which three patterns are shown in Fig. 536.

304. BALUSTERS. Balusters are intended to support the hand-rail and to prevent any one from falling over the ends of the steps; they may be made also an ornamental feature. They should be made of some kind of hardwood and may be of almost any size, although those of 1½ to 1¾-inch diameter are most frequently used. They are generally square at the ends and turned or twisted between. Twisted balusters make a very handsome railing for residences, and were much used in colonial mansions. They can now be turned by machinery at a very moderate cost. Generally two or three patterns of them are associated, as shown in Fig. 538. In open-string stairs the balusters should be doweled into the treads at the bottom and nailed or screwed to the under side of the rail. If the top of the baluster is round it should be doweled into the rail.

Fig. 538. Twisted Balusters.

Usually two balusters are placed on each step, one flush with the face of the riser and the other half-way between the risers. When the run exceeds 10 inches, three balusters to the tread have a much better appearance and in residences especially, three 1½-inch balusters give a better effect than two larger ones.

There are two methods of arranging the turned portions of the balusters in open-string stairs. One is to keep the square base the same height on each step, varying the height of the turning as shown at *A*, Fig. 524, and also in Fig. 538; the other is to make the turned part of the baluster of the same length in each, varying the height of the square part to conform to the rake of the stairs, as shown at *B*. With a close string every baluster is alike, although with this style of stair open panel-work or heavy balusters and arches are often used instead of the ordinary balusters.

305. GEOMETRICAL-STAIR CONSTRUCTION. Geometrical stairs have no newels or angle-posts. The flights are arranged around a well-hole in the center, as in the plan, Fig. 518. Each step is supported at one end by the wall-string, into which it is

housed, and at the other partly by the outer string, on which it rests, partly by the step below. The face-string is generally strengthened by a flat, iron bar screwed to its under side. The hand-rail is uninterrupted in its course from top to bottom. Fig. 539 shows a sectional elevation of a geometrical stair with winders.

Fig. 539. Sectional Elevation of Geometrical Stairs with Winders.

306. SAFETY-TREADS.* These are an ingenious device made on a rolled foundation of steel or hard brass (delta metal). On this base are upright ribs, the alternate pairs of which are dovetailed or undercut to receive a filling of lead or of some such abrasive compound as carborundum, which is bound to them by a chemical cement. They are used on stairs, landings and inclined ways, elevator and fire-door thresholds, around machinery or wherever accidents from slipping are possible.

* Made by the American Mason Safety Tread Company, Boston, Mass.

The treads if made on drawn-steel plates, ¼ of an inch thick, are in standard widths of 3 and 3½ inches, ribbed, with nosing or overhang, and of 4 and 6 inches flat. Combinations of these give any desired widths. The brass base has the same thickness and is drawn in a 2⅞-inch width, with a 1-inch nosing; in a 3½-inch width, with a short nosing; and in 3, 4 and 6-inch widths flat. The open grooves are U-shaped. Fig. 540 represents a full-size cross-section of a strip, 3½ inches wide, with a short nosing.

When applied to wood stairs the safety-treads are put on in one of the two ways shown in Fig. 541. The lower step shows a leaden tread with plain edge and inset and the upper step shows a carborundum tread with nosing, set on the top surface of the wood tread.

Fig. 540. Mason Safety Treads, Three-inch, Full Size.

The combination of a hard-metal base, to resist wear, with a soft substance or an abrasive composition held in place by hard-metal ribs, results in a durable and non-slipping surface, which is easily kept clean, wears

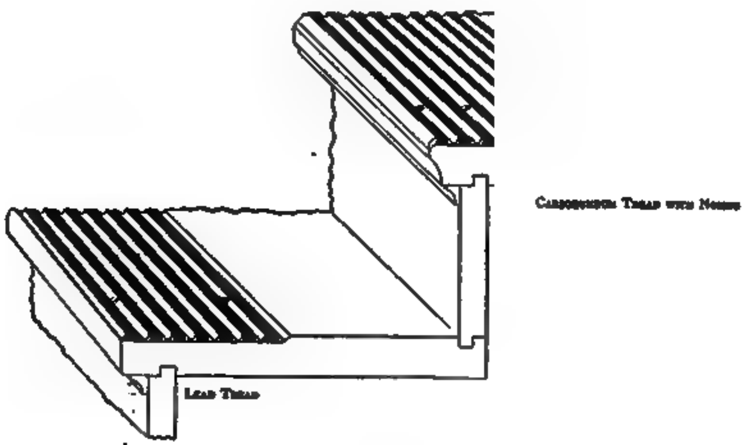


Fig. 541. Mason Safety Treads Applied to Wood Stairs.

evenly, and is sanitary and fire-proof. Such treads are in use on many of the public buildings, most of the stairways of public-service corporations and in thousands of private and semipublic buildings throughout the United States.

For general purposes the steel base is used. The double cross-hatched portions of the section shown in Fig. 540 represent the filling of lead or carborun-

dum. For use in places where an especially fine appearance is desired, the hard-brass composition replaces the steel. For exterior stone or concrete work, a galvanized-steel base may be used.

When two or more strips are joined, the joints are invisible, being at the bottom of the groove, and the surface shows as a continuous plate. When an odd width is required, it should be so arranged as to have the material cut through one of the grooves and not through the filled section. For treads of usual width the 6-inch strip answers every purpose; for extra widths, 7½ or 8-inch strips should be used. A very desirable combination, used largely in department-stores, is made of a 3½-inch strip of tread with a nosing on the front edge of each step, and back of it a 4 or 5-inch "cork carpet." The step-surface is rebated to receive these pieces.

The use of nosing is optional on ordinary stairs. It is used more for appearance' sake than for any practical advantage except that of giving a little longer life to the tread at the point where the wear is the greatest. The beveling on the edge of the safety-tread allows it to be used either on the top of the undertread or in a rebate. It is attached with screws, all necessary holes for which are punched and countersunk at the factory so that it is delivered ready to be put in place. The length of the tread is generally made 6 inches less than the width of the stairs, thus allowing a space of 3 inches at each end. The safety-treads may be made curved to any given radius.

12. FIXTURES AND FITTINGS.*

307. GENERAL REQUIREMENTS. In addition to the standing finish, the architect must usually provide for numerous fixtures and fittings for pantries, closets, etc., in dwellings, and for more or less work in connection with the plumbing. With modern plumbing little woodwork is required in connection with the fixtures, but the specifications should provide for putting up finished cleats with molded edges for all exposed plumbing-pipes and for any other woodwork necessary. For the bath-room many architects also provide for a short hook-strip with solid-bronze clothes-hooks. If the plumbing-pipes are run in pockets in the wall they should be covered with a wide board or with panel-work let flush into rebated strips and secured by iron or bronze buttons.

308. KITCHEN SINK. The specifications should also state how the kitchen sink is to be fitted up. The best plumbing to-day requires no woodwork. When slate or soapstone sinks are used there is usually no woodwork about them. Ordinary iron sinks sometimes require a wooden frame to support them and a wooden cap to cover the edges. At one or both ends of the sink a drip-board at least 18 inches long is often provided. The cap and drip-board should be at least 1⅛ inches thick and the drip-board

* See, also, Arts. 28, 29 and 235 for the kinds of wood used.

should be slightly inclined and grooved on top. The space under the sink is left open and an apron, 4 inches wide, is fitted under the cap to cover the rough frame.

309. CLOSETS. 1. *Bed-Room Closets.* All bed-room closets should be fitted with strips and clothes-hooks, and at least one shelf. Large closets are often provided with a case of drawers with three or four wide shelves above them.

2. *Linen-Closets.* Every large residence should be provided with a linen-closet fitted with a case of deep drawers and as many shelves, 16 inches wide and about as many inches apart as there may be room for. It is desirable to enclose the shelves with paneled doors as a protection from dust.

3. *Cedar Closets.* The most complete residences are also provided with a cedar closet, for the reception of articles that might be injured by moths. To be effective the entire inside of the closet, floor, walls and ceiling, should be lined with ½ or ⅝-inch cedar ceiling, and the inside of the door should also be ceiled or veneered with the same wood. Such a closet is usually fitted with one or more cases of wide and deep drawers, with wide shelves above enclosed by doors. The shelves and doors should be of cedar, but where economy is necessary the drawers may be of some cheaper wood suitable for the purpose, thinly lined with cedar. Drawers lined in this way are sometimes placed in an ordinary closet, but as it is the odor as well as the bitter taste of the cedar that keeps away the moths, it is desirable that the entire closet be protected with it. The cedar which should be used for this purpose is the Florida or Alabama red cedar. (See, also, Art. 47.)

Besides the above there are often one or more special closets whose fittings should be fully described. Detail drawings are not usually necessary for any of these fittings, as they may be described with sufficient accuracy in the specifications to ensure satisfactory construction.

310. CHINA-CLOSET OR BUTLER'S PANTRY. The arrangement and extent of the fittings for this closet or room will, of course, depend largely upon the plan and the character of the house.

A reasonably complete china-closet should have across two sides of the room a counter-shelf about 28 inches wide and 2 feet 8 inches from the floor. Below this shelf should be drawers to receive the table-linen, one long one for table-cloths and shorter ones for napkins, etc. One drawer should also be divided for knives, forks and spoons. If there is room, one or two cupboards should also be provided beneath the counter-shelf. Above the wide shelf there should be a number of shelves, 14 inches wide, for china and

glassware. These shelves should be enclosed with glass doors, sliding doors generally being considered the most convenient. A well-equipped butler's pantry should also be provided with a small sink for washing the china, glass and silver. (See, also, Art. 316.)

311. KITCHEN PANTRY. This room should be fitted with a counter-shelf as long as the space will permit, with cupboards and at least one case of drawers about 3 feet long under it and open shelves above. A strip for pot-hooks is often provided. Provision should also be made in the pantry for flour. Where flour is sold by the barrel, as is the case in the eastern states, it is customary to construct a cupboard under the counter-shelf, with a door large enough to admit the barrel and a lifting cover in the counter-shelf through which the flour can be reached. Pivoted clamps or barrel-swings are often used for flour-barrels, by means of which one can swing the barrel out of the closet instead of reaching for it through a door in the shelf. It is almost impossible for a person of average height to reach the bottom of a flour-barrel through a hole or door in the counter-shelf. Fig. 544 shows the "Perfection" barrel-swing* attached to a flour-barrel. It will swing a barrel containing 400 pounds of flour. There are two spurs on the inner edge of the projecting flange of the swing which prevent the fixture from slipping off the barrel.

In many of the extreme western states flour and meal are sold only in cotton bags containing either 25 or 50 pounds, and in those states it is customary to put "flour-bins" under the counter-shelf, one for flour and one for meal. These bins are tight boxes about 18 inches wide, 16 inches deep and 2 feet 3 inches high, and are pivoted so that the top may be brought forward for taking out the meal or flour and then pushed back under the shelf. Such bins are very convenient, but mice sometimes find their way into them, and for this reason many housekeepers prefer to keep their flour in tin cans made especially for the purpose. If such cans are to be used, provision should be made for them in the pantry. (See, also, Arts. 315 and 316 and Fig. 542.)

312. KITCHEN DRESSER. In many small houses there is room only for one closet, which is made to serve for both china-closet and pantry. When this is the case it is desirable to have a dresser in the kitchen in which the kitchen utensils may be kept, and many housekeepers prefer a good dresser to a kitchen pantry. The dresser is usually made about 8 feet high and from 5 to 10 feet long, according to the size of the kitchen. It should be divided into an upper and a lower section by a counter-shelf at least

* Patented and manufactured by the Leavitt Machine Company, Orange, Mass.

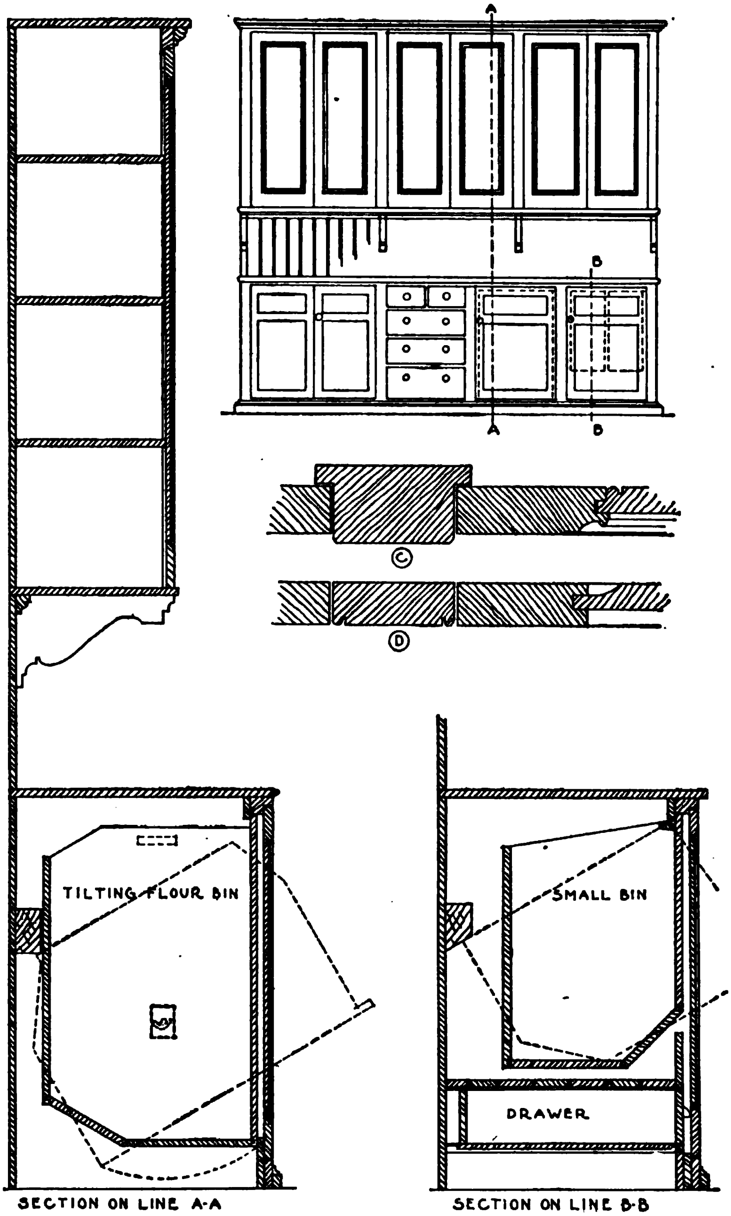


Fig. 542. Kitchen or Pantry Dresser and Flour-Bin.

20 inches wide. The section below the counter-shelf should have a place for flour and two or three drawers, and the remainder of the space should be finished off for cupboards for pots and pans and enclosed with paneled doors. Above the counter-shelf level there should be about four shelves 12 or 14 inches wide. These shelves should always be enclosed with glazed doors, arranged either to slide by each other on brass tracks or to be hung with hinges at the sides. The width of swinging doors should not exceed 18 inches and a width of 15 inches is about the most convenient; the doors should be arranged in pairs. Sliding doors may be from 18 inches to 2 feet wide. When the counter-shelf is narrow it is a good idea to arrange for a drawer-shelf immediately under the counter-shelf which may be drawn out when needed. As a dresser is really a piece of furniture, although generally fixed in place, it should be neatly made, with paneled doors and ends, and finished on top with a simple cornice. The wood should be the same as that used in finishing the room.

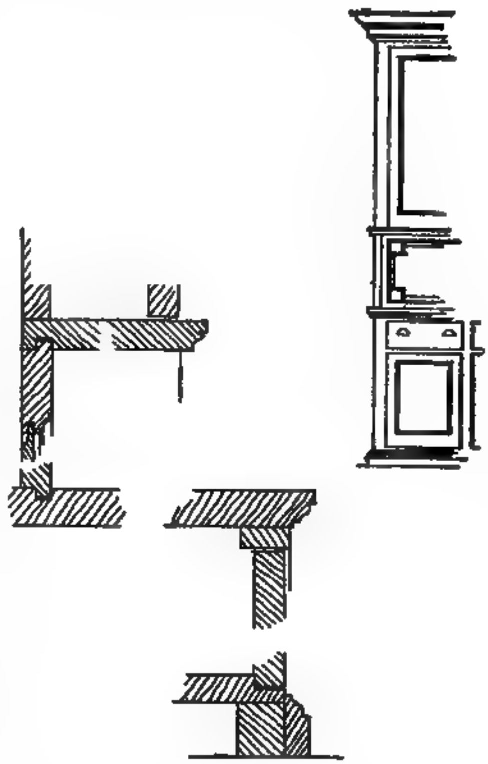


Fig. 543. Kitchen or Pantry-Dresser Details.

To insure the best arrangement of doors, cupboards, drawers, etc., for the pantry, china-closet or dresser, the architect should make scale drawings that will show the fittings at the different sides of the rooms, with full-size sections for any special moldings or details. Figs. 542* and 543* show kitchen or pantry dressers with various appropriate details. The requirements, and consequently the arrangement of parts, vary with the domestic

* Redrawn and adapted, by permission, from "Details of Building-Construction," C. A. Martin.

customs of each household. The details of planning and arrangement of parts require a consideration of china, table-linen, silver, cutlery, kitchen utensils, food-stuffs, flour-bins, kneading-boards, spaces for dining-room-table extension-leaves, drawers, cupboards, shelves, etc. Some of the constructional details are referred to in Arts. 315 and 316.

313. CLOTHES-CHUTE. In many residences a clothes-chute is provided, which runs from some place in the second story, from the bath-room when practicable, to the laundry. The chute is merely a vertical shaft or well about 16 inches by 2 feet inside, lined with matched ceiling and provided with doors in each story.

314. DUMB-WAITER. If a dumb-waiter is required, a shaft with doors opening at the proper level in the different stories, must be provided to enclose it. The shaft should be ceiled inside and have, if necessary, a pocket for the weights. Access to the latter should be had through pocket-pieces secured with screws.

Fig. 544. The "Perfection" Barrel-Swing.

In buildings having the kitchen below the dining-room, a dumb-waiter is a necessity for serving the meals, and even where a dumb-waiter is not needed from kitchen to dining-room, it is a great convenience to have one running from cellar to kitchen or from laundry to upper stories.

The dumb-waiter, as originally constructed, consisted of a box, suspended by a rope which hung over a pulley and had a weight attached to the other end. More pulleys and ropes were added, until their number and the friction they created became a nuisance.

An improved type of dumb-waiter was then invented. This type works on two wheels mounted on a shaft which revolves in two bearings. A rope connecting the dumb-waiter box and a slightly heavier counterweight passes over the smaller of these two wheels, which is called the "lift-wheel"; and an endless rope called the "hand-rope" for operating the machinery, hangs over the larger wheel, which is conventionally called the "hand-wheel." The car and counterweight are kept in place by means of runs or strips of wood which must be put up plumb and true if satisfactory service is to be had.

There are three types of control in general use. The oldest is a clamp or check operating on the hand-rope and applied and released by the operator. A second type of machine is fitted with a hand-brake, which operates on a

brake-wheel attached to the main shaft of the dumb-waiter machine, and is applied or released by the operator by means of a "brake-line." The third

Fig. 545. Dumb-Waiter with Automatic Brake.

Fig. 546. Sedgwick Automatic Dumb-Waiter.

type of machine is fitted with an automatic brake which is operated by the machine itself, independently of the operator, and makes it impossible for the box to run away, either up or down, irrespective of whether the dumb-waiter is empty or loaded.

It is advisable to purchase complete outfits, comprising dumb-waiter car, machine, weight, ropes and runs, from reliable manufacturers; and if these are installed in accordance with directions furnished by the manufacturers, satisfactory results may be expected. The prices of complete dumb-waiter outfits range from $25 upward and depend upon size, capacity, etc.

Manufacturers of dumb-waiters make similar machines of every type and for all purposes, but the three types above described are adapted to most situations. For hospitals, hotels, restaurants, etc., where heavier loads are to be handled than in the ordinary private house, a geared machine should be used, and the car should be suspended by means of a wire cable, not by a Manila rope. These geared machines are fitted with either improved self-locking and indestructible hand-brakes or with automatic brakes, at the option of the purchaser. Hand-power elevators, which are similar to these machines, are installed in many large houses where the carrying of trunks, etc., up and down is not only laborious but detrimental to the finish of walls and stairs; and hand-power elevators for carriages, automobiles, hay, oats, etc., in stables and garages are practical and frequently used.

The size and shape of the dumb-waiter car may be varied to suit the space available and the service required. The common size for residences is 24 inches wide, 20 inches deep and 30 inches high, with two fixed shelves. For tenement and apartment-houses the car may be made 30 inches wide and 3 feet high, with one hinged shelf, so that a barrel may be set in it if desired. The shaft should be at least 3 inches larger both ways than the car, and should be ceiled or plastered on the inside. If the weight runs between double guides, no extra space is required in the shaft, and the weight is readily accessible. Figs. 545 and 546 show the working-mechanism of the third type of dumb-waiter mentioned above.*

Most dumb-waiters may be made "double-face," that is, with openings on opposite sides for different stories, and they can also be adapted to openings on adjacent sides; but this arrangement should be avoided. The doors at the openings into the dumb-waiter shaft are usually hung with cords and weights in the same manner as an ordinary window, and are provided with some form of spring-catch which will hold the door either up or down.

315. DETAILS OF CUPBOARDS, BOOKCASES, CABINETS, ETC.† In order to detail properly a case of drawers, cupboard-doors, etc., the draughtsman must be familiar with the different methods of constructing them. Cupboard-doors are made in essentially the same way as other doors, except that they are usually thinner and have narrower rails and stiles, and the panel-mold is worked on the solid wood. For a door 2 by 4½ feet or less, a thickness of 1⅛ inches is ample, while the stiles and rails

* Courtesy of the Sedgwick Works, New York City.

† See, also, Fig. 386 and Arts. 310, 311 and 312.

should be about 2½ or 3 inches wide; the lower rail is usually made 1 inch wider than the others. The panels should not be over 12 inches wide, 8 or 10 inches being the better widths. A door 2 feet wide and over 3 feet high should have four panels.

When doors are used in pairs the meeting-rails are usually rebated and beaded. If the doors are arranged to slide, a slight space must be left between them, about $^3/_{16}$ of an inch, and a stop-bead nailed to the edges to keep out the dust, as shown in Fig. 547. The outer edges of the door should also fit into a groove in the frame for the same reason. When dust-proof swinging doors are desired, the edges of the doors should be fitted approximately as shown in Fig. 548, with the meeting-stiles rebated and the joint covered with an astragal.

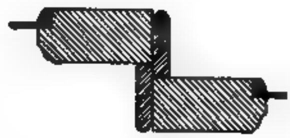


Fig. 547. Detail of Sliding Cupboard-Doors and Frame.

Fig. 542 shows a vertical section *AA* through a dresser from cornice to floor, through cornice, cupboards and shelves, counter-shelf, tilting flour-bins and base. It also shows a vertical section through an alternate arrangement for a smaller flour-bin with one drawer below it. The doors of the cupboards above the counter-shelf may be paneled or glazed, but glazing is preferable. The brackets under these cupboards may be short, as shown, or may be made larger and come down to the counter-shelf. Drawings *C* and *D* are horizontal sections through the frames, door-stiles and panels of the cupboards, detail *D* being for poorer, cheaper work, and detail *C* for better construction.

HANGING STILE.

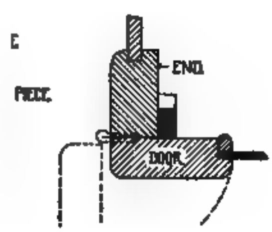
Fig. 548. Detail for Dust-Proof Cupboard-Doors.

The drawings of the flour-bins show their general construction. They turn on metal pivot-hinges placed a little nearer to the front than to the back of the bin so as to allow the weight of the contents to close it. A drawer-pull is usually placed on the outside face of the bin near the top and the pivot-hinge allows the bin to

be taken out for cleaning. The block shown at the back of the bin prevents the latter from tipping forward too far. (See, also, Art. 311.)

Fig. 543 shows the elevation, in part, of another variation of dresser design, and also a vertical section illustrating one method of putting together the pieces which form the cornice, frame, doors, paneled backing, counter-shelf and base. This detail shows a more elaborate cornice than usual. The details used by different architects vary greatly.

The ordinary method of hanging the doors of cases, cabinets, etc., is shown at *A*, Fig. 549. For bookcases, or wherever it is desirable to utilize the full width of the opening, there is a serious defect in this method, in that when the door is open at right-angles the opening is reduced by the width *X*, or nearly the entire thickness of the door. To obviate this the door may be hung as shown



A B C

Fig. 549. Methods of Hanging Doors of Bookcases and Cabinets.

at *B* or *C*. The last detail is intended to represent the jamb of a bookcase finished with pilasters at the angles, which are made a

A B C

Fig. 550. Pivoted Bookcase-Doors.

part of the doors instead of being fastened to the case, and thus uncover the whole length of the shelves when the door is opened.

Very often, on bookcases and fine cabinets, it is desirable that the hinge shall not be seen; in this case the pivot or pin-hinge is

used. Bookcase doors are frequently pivoted, as shown at *A*, Fig. 550. In locating the pivot the distance *D* should be about 1/16 of an inch more than the distance *B*. For a bookcase, however, this method of pivoting the doors is decidedly objectionable for several reasons: it narrows the opening by the full width of the door; the shelves must be made narrower than with swinging doors; and dust easily enters at the edge of the door. A much better arrangement is that shown at *B*, which leaves the full width and depth of the case available.

At *C* is shown what is probably the best method of hanging or pivoting the lid of a small desk or cabinet that opens down. By this arrangement the lid is made self-supporting when open, without the aid of elbow-braces or chains, and the pivot-hinge can be made quite strong and invisible.

316. DETAILS OF DRAWERS. Drawers form a part of many of the fittings designed by the architect, and the better methods of construction should be familiar to every draughtsman.

The successful operation of a drawer depends upon the construction both of the drawer and of the case in which it works. The case should be so made that there will be only sufficient contact with the drawers to support and guide them. Fig. 551 shows the usual construction of the case with top omitted. The bottom edge of the drawer slides on the piece *A*, while the piece *B* guides it. The piece *C*, which separates the drawers, is usually but ¾ of an inch or 1 inch thick. If a greater space is desired between the drawers a strip is glued to the edge as at *D*.

Fig. 551. Drawer-Frame or Case.

Long drawers are often made with a center guide, as shown at *G*. Blocks are glued to the bottom of the drawer to slide along each side of the guide. Long and shallow drawers work much better with such a guide, and the guide also serves to support the bottom. In the best work a "dust-panel" is placed in the frame between the drawers so that when a drawer is removed from the pocket it is impossible to reach the contents of the drawer below; the panel also keeps out more or less dust. If it is desirable that the drawer

may be withdrawn its entire depth without falling, sliding-pieces, *S*, may be arranged at each side of the drawer, in the manner shown in Fig. 552. As the drawer is drawn out it slides first on the sliding-pieces *S*, and when half open, a pin, *P*, catches in each sliding-piece and draws it out. The pieces *S* hold the drawer, keep it from falling, and are prevented from tipping by the shoulders *R*, which bear against the under side of the piece *A*, Fig. 551.

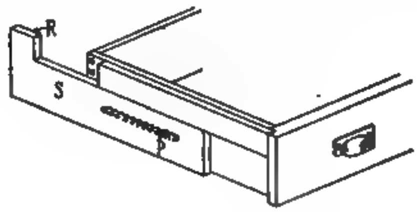


Fig. 552. Drawer with Sliding-Pieces.

Fig. 553 shows the "Kimball" ball-bearing drawer-slide, which has been much used. It is similar to the arrangement above described, but has steel balls inserted in grooves to decrease the friction. One objection to this type of drawer-slide, however, is the

Fig. 553. Kimball Ball-Bearing Drawer-Slide.

wearing of the wood by the steel balls after some use and the consequent coming together of the wood pieces, which renders the balls useless. Drawer-slides are quite extensively used in libraries and public buildings; they are worthy of a more extended use in dwellings and for all drawers that are to be much used. The "Turner" patented anti-friction drawer-slides * have their wheels extending through the sliding-strips *C*, Fig. 554. When the drawer is loaded, it bears upon the wheels entirely and does not wear away

* Made by the Grant Pulley and Hardware Company, New York City. This company makes the "Baker" Draw-Slide also.

nor allow the wood to rub and bind. This slide, also, has a wheel at the back end of each sliding-strip, which rolls and keeps the drawer from dropping when drawn out full length.

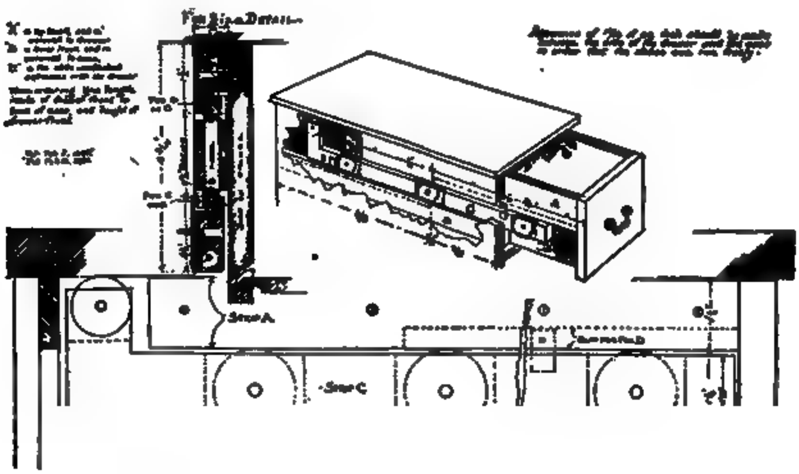
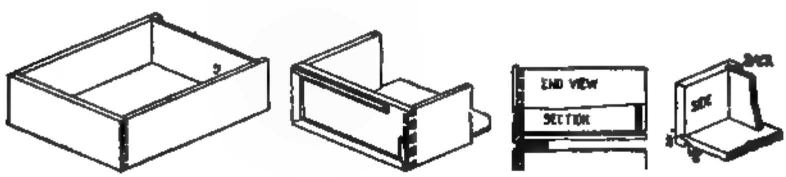


Fig. 554. The "Turner" Drawer-Slide.

The construction of the drawer itself is quite simple, the variations being only as a rule in the front piece and in the joints. The sides and back of the drawers are usually from $\frac{7}{16}$ to $\frac{5}{8}$ of an inch thick, and the bottom from $\frac{3}{8}$ to $\frac{1}{2}$ of an inch thick. The



Plain-Front Drawer. Panel-Front Drawer. Lip-Front Drawer. *D.*

Fig. 555. Details of Drawer-Construction.

drawers slide on the bottom edges of the side pieces and the bottom is grooved into the front and sides. The back is commonly tenoned or grooved into the sides and rests on the bottom. The bottom should always have the grain of the wood running across the drawer, and should extend a little beyond the back-piece to allow for shrinkage. It should not be fastened except at the front.

A drawer may have a plain front, a panel-front or a lip-front, as shown in Fig. 555. The panel-front is usually formed by nailing or gluing a panel-mold around the edges of a plain front. When the drawer is pushed back the molding is flush with the front of the case. If the front and sides are connected by a full dovetail joint this makes a very strong and handsome drawer. The face of a "lip-front" drawer is rebated around all four edges, so as to project about ¼ of an inch over the face of the case to keep out dust. The lip-front drawer should be used where the appearance is not of great consequence and where it is desirable to keep out dust as much as possible, as in drawers for linen, clothes, etc. Lip-front and plain-front drawers are usually lap-dovetailed to the sides, as shown in the illustrations. (See Fig. 356.) Carpenters often simply rebate the ends of the front and nail the sides in the rebate, but this makes a bungling piece of work, and the nails are apt to split the sides.

In furniture-work the back and sides of the drawers are usually dovetailed together, but in most millwork they are simply grooved and nailed together, as at *D*, Fig. 555. The groove in the side pieces for the bottom should be kept up ⅜ of an inch from the lower edge. If the bottom piece must be more than ¼ of an inch thick, it may be cut away at the edges as shown.

Specifications for drawers should state the kind of front desired and the method of joining the parts.

When a drawer is hung from a table-top or shelf, the best arrangement for the slide is that shown in Fig. 556. If the slide is placed at the top of the drawer there is sure to be friction against the under side of the table-top unless the drawer is loosely hung, and this too is objectionable.

A drawer for a corner-cabinet cannot, of course, be made to slide but it may be pivoted to work as in Fig. 557.

Fig. 556. Detail of Drawer Hung from Table-Top.

317. MANTELS AND SIDEBOARDS. The details of mantels and sideboards depend almost entirely upon the design, and as this may vary indefinitely it is impossible to give many illustrations that would be of much value. In general the same principles of construction that have been given for cabinet-work or finish apply to these fixtures.

Fig. 558 * shows the design and construction of the upper part

* Redrawn and adapted, by permission, from "Building Details," Frank M. Snyder.

of a wood mantel in the residence of Miss Dunning, at Briercliff Manor, N. Y., designed by Mr. H. Van Buren Magonigle. The mantel is set against concrete and secured to the grounds and wood blocks as shown. The sizes of the pieces used and the jointing are indicated in the vertical and horizontal sections. The shelf-molds are mitered across the ends and the shafts of the columns are hollow and built up of four fluted pieces splined together. The wood finish is white pine painted white and the facing of the fireplace opening is of Pavonezza marble. The mantel-shelf is 1½ inches thick; the frieze-piece and piece above the shelf, ½ an inch; and the backing-piece, back of the frieze, 1⅛ inches.

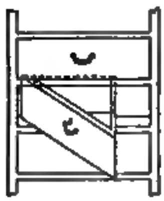


Fig. 557. Drawer in Corner Cabinet.

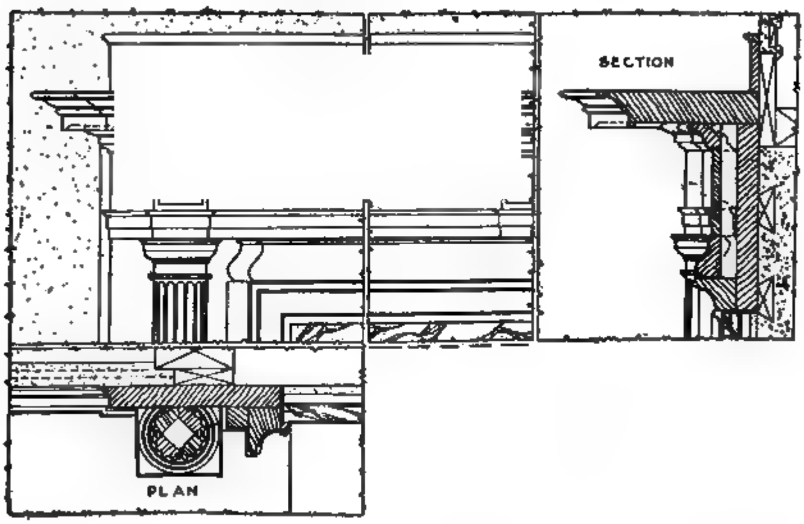


Fig. 558. Details of Mantel in Residence at Briarcliff Manor, N. Y.

13. DIMENSIONS OF FURNITURE.

318. DIMENSIONS OF FURNITURE. For the convenience of draughtsmen when designing furniture or providing space for a special article, the following dimensions, furnished by Mr. Alvin C. Nye, are given: *

1. *Chairs and Seats.* The average figures taken from a variety of good chairs are: height of the seat above the floor, 18 inches; depth of the seat,

* These dimensions were first published in the "*American Architect*" of November 10, 1894.

19 inches; height from the floor to the top of the back, 38 inches. Usually the seat increases in depth as it decreases in height, while the back is higher and slopes more. Twenty inches inside is a comfortable depth for a seat of moderate size. Chair-arms are about 9 inches above the seat. The slope of the back should not be more than one-fifth the depth of the seat. A lounge is 6 feet long and about 30 inches wide.

2. *Tables.* Tables vary in shape and size almost as much as chairs. Writing and dining-tables are made 2 feet 5 inches high, and the type of sideboard called a carving-table is made 3 feet high to the principal shelf; but tables for general use are 2 feet 6 inches high.

Dining-tables may be lengthened to 12 or 16 feet by means of slides within the frame. This frame should not be so deep as to interfere with the knees of any one sitting at the table; that is, there must be about 2 feet clear space between it and the floor.

The smallest size practicable for the knee-holes of desks and library tables is 2 feet high by 1 foot 8 inches wide, and the width should be increased as much as possible.

3. *Bedsteads.* Bedsteads are classed as single, three-quarters and double. A single bed is 3 to 4 feet wide inside; a three-quarter bed, from 4 to 4 feet 6 inches; a double bed, 5 feet. All bedsteads are from 6 feet 6 inches to 6 feet 8 inches long inside. Footboards are from 2 feet 6 inches to 3 feet 6 inches, and headboards from 5 feet to 6 feet 6 inches high.

4. *Bureaus.* Bureaus vary in shape and size to such an extent that it is impossible to say that any dimension is fixed. Convenient sizes are: 3 feet 5 inches wide, with body 1 foot 6 inches deep and 2 feet 6 inches high; or 4 feet wide, with body 1 foot 8 inches deep and 3 feet high.

5. *Commodes.* Commodes are 1 foot 6 inches square on the top and 2 feet 6 inches high.

6. *Chiffoniers.* Chiffoniers are 3 feet wide, 1 foot 8 inches deep and 4 feet 4 inches high.

7. *Cheval-Glasses.* Cheval-glasses are made, if large, 6 feet 4 inches high and 3 feet 2 inches wide; if small, 5 feet high and 1 foot 8 inches wide; if medium, 5 feet 6 inches high and 2 feet wide.

8. *Washstands.* Washstands of large size are 3 feet long, 1 foot 6 inches wide and 2 feet 7 inches high. Small-size washstands are 2 feet 8 inches long.

9. *Wardrobes.* Wardrobes may be 8 feet high, 2 feet deep and 4 feet 6 inches wide; or 6 feet 9 inches high, 1 foot 5 inches deep and 3 feet wide.

10. *Sideboards.* Sideboards may be 5 to 6 feet long and are about 2 feet 2 inches deep.

11. *Pianos.* Upright pianos vary from 4 feet 10 inches to 5 feet 6 inches in length; from 4 feet to 4 feet 9 inches in height; and are about 2 feet 4 inches in depth, over all. Square pianos are about 6 feet 8 inches long by 3 feet 4 inches deep.

Of course this list could be supplemented with an almost endless number of article of furniture.

14. FLOORS.*

319. OVERFLOORS OR FINISHED FLOORS. (For data relating to "Underfloors or Subfloors," see Art. 213.) When double floors are used, as they should always be in the better class of dwellings, the overflooring or finished flooring should not be laid until the plastering is thoroughly dry and most of the standing finish in place. When hardwood floors are used they should not be laid until all the other carpentry-work in the room is finished. When there is to be only a single floor it is customary to lay the floors that are to be carpeted before plastering, and put off laying the hardwood floors, or those that are to be finished, until after the plastering is dry. Great care should be exercised to have the building, in which hardwood flooring is to be laid, thoroughly dried out before the flooring is put into it and to maintain as even a temperature as possible during the process of laying. As hardwood flooring is thoroughly kiln-dried, if exposed to moisture the tongues and grooves will swell up and make it difficult to get the boards together. Then after being laid they will shrink and leave unsightly cracks.

320. WOODS USED FOR FLOORING. For floors that are to be carpeted spruce boards have been and still are commonly used in New England. In the middle and northwestern states white pine was in general use until the decreasing cut and increased cost drove it from many markets and caused cheaper woods to be substituted. In these states now, in the trans-Mississippi states and in the southern states hard pine is more commonly used. Douglas fir is very extensively used for flooring in the Pacific Northwest. For kitchen-floors, and wherever a good wearing floor is desired that will not incur the expense of hardwoods, long-leaf southern pine may be used. All boards containing sap or large streaks of dark turpentine should be culled out, as the turpentine soon crumbles away and leaves unsightly depressions. For floors that are subject to a great deal of wear, maple is generally considered the best wood, although it is sensitive to atmospheric changes and therefore not much used in parquetry-flooring. For floors of parlors, halls, living-rooms, etc., oak is generally preferred. Besides these woods, birch, beech, walnut, cherry, poplar, whitewood,

* Much valuable data, on the subject of flooring has been obtained from the following:
The Wood Mosaic Flooring and Lumber Company, Rochester, N. Y.
The T. Wilce Company, Chicago, Ill.
The Hardwood Record, Chicago, Ill.
The Oak Flooring Manufacturers' Association of the United States, Detroit, Mich.
The Yellow Pine Manufacturers' Association, St. Louis, Mo., and various other associations handling different woods. (See, also, Arts. 213 to 215.)

sycamore, gum, cypress and some other woods are used in different parts of the country. Ash and chestnut, also, have been used for flooring, but are not good woods for this purpose as the surface tends to sliver and split off. For all floors that are not to be carpeted, quarter-sawed flooring should be specified, as bastard boards tend to sliver and warp.

321. MATCHED FLOORING. It is always advisable to have double floors, but if only a single floor is used it is absolutely necessary that the boards be matched to prevent currents of air from coming up from the spaces between the joists, and oak or other ornamental floors must be matched in order that they may be blind-nailed. For other floors it has been claimed by many that matching is not really necessary, and in many parts of New England it was for a long time customary to match only hardwood flooring. Instead of matching the spruce and hard-pine flooring the boards were carefully "jointed" or planed so that their edges came tightly together and the nails were driven in from the top and sunk with a nail-set, if the floor was to be dressed off. When the material and workmanship were of the best this really made a better floor than the ordinary matched flooring. A jointed floor thicker than $\frac{5}{16}$ of an inch, is now, however, seldom seen. In the western states nothing but matched flooring is seen. Formerly a great amount of the flooring was so poorly matched that it could be made to come together only by rejointing by hand, but owing to the improvements made by the introduction of fine machinery in the manufacture of boards for ordinary as well as for parquet-flooring, these imperfections have been largely removed.

322. WIDTHS, THICKNESSES AND LENGTHS OF BOARDS FOR FLOORING. For ordinary flooring (other than hardwood, parquetry or parquet-flooring, not to be carpeted) the width of the boards should not exceed 4 inches and a maximum of 3 inches is better.* For hardwood flooring, other than parquetry or parquet-flooring, the ordinary finished or "face"-widths do not exceed $3\frac{1}{4}$ inches for maple and $2\frac{1}{4}$ inches for oak, beech, birch, walnut and cherry, and all are now made as narrow as $\frac{7}{8}$ of an inch in $\frac{3}{8}$ of an inch thickness. For carpeted floors greater widths will answer, if a good quality of soft pine, Douglas fir, or well-seasoned spruce is used; otherwise 3 or 4-inch flooring in such woods should be specified, for if a wide board warps much it will form ridges against which the carpet will wear. Ordinary flooring is $\frac{13}{16}$ of

* Flooring is commonly designated by the width of the board from which it is stuck, 4-inch, jointed flooring measuring about $3\frac{3}{4}$ inches, and matched flooring about $3\frac{1}{4}$ inches, face-measure. A $\frac{13}{16}$ by $1\frac{1}{2}$-inch flooring-board is measured as a 1 by 2-inch board in oak and as a 1 by $2\frac{1}{4}$-inch board in maple, beech, birch, walnut or cherry.

an inch thick, its under side sometimes left rough; but for stores, public corridors and similar places thicker flooring in such woods as pine, spruce and maple is often used, both for stiffness and durability. Special maple flooring is made 1 1/16, 1 5/16 and 1 13/16 inches thick. Douglas fir flooring is made in 1 by 3, 1 by 4, 1 by 6, 1 1/4 by 4 and 1 1/4 by 6-inch sizes, finished in face-sizes of 13/16 by 2 1/4, 13/16 by 3 1/4, 13/16 by 5 1/8, 1 1/16 by 3 1/4 and 1 1/16 by 5 1/8 inches, respectively. Yellow pine flooring is made in 1 by 3, 1 by 4, 1 by 6, 1 1/4 by 4 and 1 1/4 by 6-inch sizes, finished in face-sizes of 13/16 by 2 1/4, 13/16 by 3 1/4, 13/16 by 5 1/4, 1 3/32 by 3 1/4 and 1 11/32 by 5 1/4 inches.

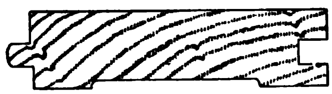


Fig. 559. Grooved, Matched Flooring.

The question of length is not considered of such great importance as formerly as the process of end-matching has eliminated the necessity of using long pieces only. The lengths of the various hardwood boards used for flooring run up to 16 feet.

The 7/16-inch and greater thicknesses of ordinary matched flooring are sometimes grooved on the under side, as in Fig. 559, to make them conform to the floor more readily or to enable the carpenter to lay the flooring more easily and quickly. The claim has also been made that the grooving tends to prevent warping. Some manufacturers of the best flooring, however, never undercut or undergroove their tongued-and-grooved flooring. Fig. 560 shows some full-size sections of hardwood flooring-boards of different widths and thicknesses. End-matched flooring is shown in Fig. 561. This makes a more even joint than the butt-joint and does not have to be nailed through the top. Although with end-matched flooring it is not absolutely necessary to have a subfloor with the 13/16-inch thickness, or to have the joints came over a joist, it is always advisable to so arrange them.

323. QUALITIES OF WOODS USED FOR FLOORING. GRADING-RULES FOR FLOORING. The associations manufacturing flooring from different kinds of wood publish "Rules for Grading," to which the reader is referred for full details relating to the various qualities of flooring and the actual widths, thicknesses and exact meaning of terms for accurate specifying. In order to illustrate these classifications, however, the following extracts from some of the latest compilations are added:

1. *Yellow Pine Flooring Grading-Rules.** Yellow pine shall be classified

* From "Yellow Pine. A Manual of Standard Wood Construction," published by The Yellow Pine Manufacturers' Association, St. Louis, Mo.

as to grain as "edge-grain" and "flat-grain." Edge-grain has been variously designated as "rift-sawed," "vertical grain," "quarter-sawed," all being commercially synonymous terms. Edge-grain stock is especially desirable for

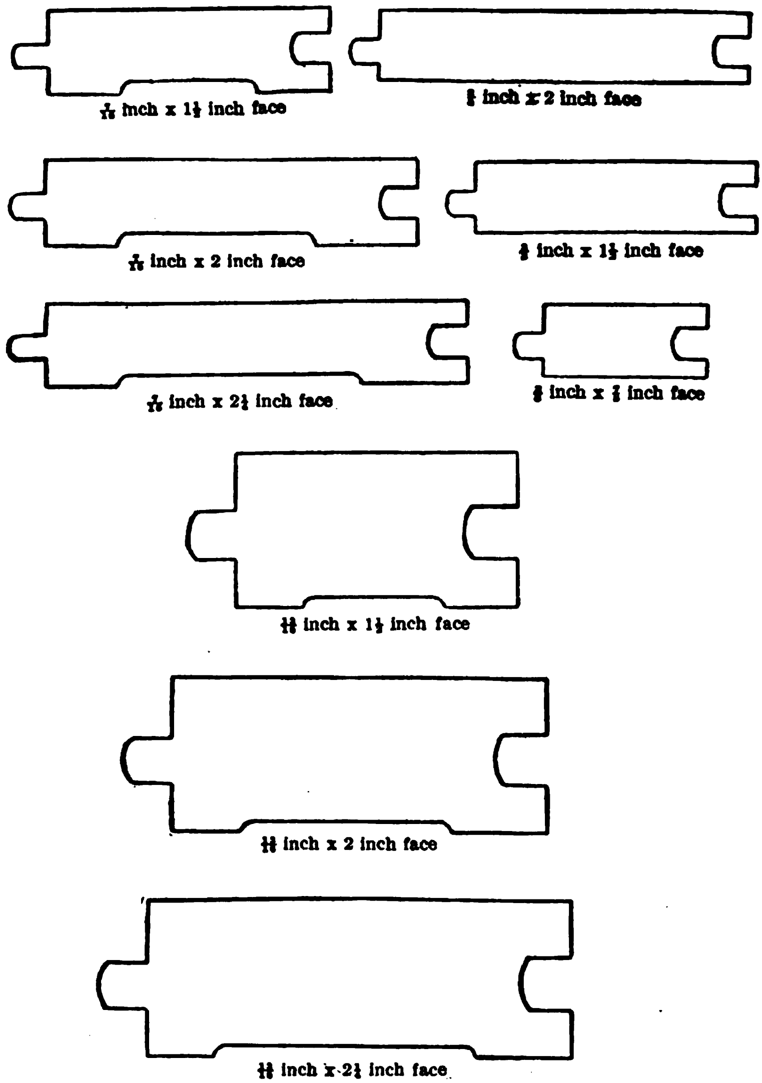


Fig. 560. Full-Size Sections of Hardwood Flooring-Boards.

flooring and admits no piece in which the angle of the grain exceeds 45 degrees from the vertical at any point, thus excluding all pieces that will

sliver or shell from wear. Such as will not meet these requirements shall be known as "flat grain."

All dressed stock shall be measured and sold "strip-count," namely: full size of rough material necessarily used in its manufacture. All sizes 1 inch or less in thickness shall be counted as 1-inch thick.

Fig. 561. End-Matched Flooring.

Knots shall be classified as "pins," "standard" and "large," as to size; as "round" and "spike" as to form; and as "sound," "loose," "encased," "pith" and "rotten" as to quality.

Pitch-pockets are openings between the grain of the wood containing more or less pitch or bark, and shall be classified as "small," "standard" and "large" pitch-pockets.

A "pitch-streak" is a well-defined accumulation of pitch at one point in the piece, and when not sufficient to develop a well-defined streak, or where fiber between grains is not saturated with pitch, it shall not be considered a defect.

"Wane" is bark, or the lack of bark or a decrease of wood from any cause on the edge of the piece.

"Bright sap" shall not be considered a defect in any of the grades provided for and described in these rules. The restriction or exclusion of bright sap constitutes a special class of material which can only be secured by special contract.

"Sap grain" shall not be considered a defect in any of the grades of common lumber.

"Firm, red heart" shall not be considered a defect in any of the grades of common lumber.

"Chipped grain" consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found should not be classed as "torn grain" and shall not be considered a defect.

"Torn grain" consists in a part of the wood being torn out in dressing. It occurs around knots and curly places, and is of four distinct characters: slight, medium, heavy and deep.

"Loosened grain" consists in a point of one grain being torn loose from the next grain. It occurs on the heart-side of the piece, and is a serious defect, especially in flooring.

The standard lengths are multiples of two feet, from ten to twenty-four feet, inclusive, for boards, fencing, dimension lumber, joists and timbers; multiples of one foot, from ten to twenty feet inclusive, for finishing, flooring, ceiling, siding, partitions, casings, bases, window and door-jambs, except as hereinafter specified. Longer or shorter lengths than those herein specified

are special. Special and fractional lengths, when ordered, shall be counted as the next higher standard length.

The standard of widths for lumber, S 1 S* or S 2 S or rough, excluding dimension lumber, shall be multiples of 1 inch, from 3 inches and up in width.

On stock-width shipments of No. 1 Common and better lumber, either rough or dressed one or two sides, no piece should be counted as of "standard width" that is more than 1/4 of an inch scant on 8-inch and under; 3/8 of an inch scant on 9 and 10-inch, or 1/2 of an inch scant on 11 and 12-inch or wider lumber. Such pieces should be measured as the next lower standard of width and not reduced in grade.

No arbitrary rules for the inspection of lumber can be maintained with satisfaction. The variations from any given rule are numerous and suggested by practical common sense; so nothing more definite than the general features of different grades should be attempted by rules of inspection. The grading-rules, therefore, are submitted as the general characteristics of the different grades.

Sizes of Flooring. D grade and better, 1 by 3, 1 by 4 and 1 by 6 inches shall be worked to 13/16 by 2 1/4, 3 1/4 and 5 1/4 inches; 1 1/4-inch flooring shall be worked to 1 3/32 inches thick; 1 1/2-inch flooring to 1 11/32 inches thick, the same width and the same matching as 1-inch stock.

Lengths of Flooring. Standard lengths are from 8 to 20 feet in B and better flooring with not to exceed 5 per cent of 8-foot lengths in mixed-

* The following are some of the abbreviations used in grading and shipping woods for flooring and other purposes:

T & G	Tongued-and-grooved.
B M	Board (that is, 1-inch)-measure.
S F	Superficial feet, same as B. M.
S M	Surface-measure.
E G	Edge-grain; either vertical or within an angle of 45 degrees from the vertical.
V G	Vertical grain.
F G	Flat grain; nearly parallel with surface; or other than edge-grain.
D & M	Dressed-and-matched, that is, surfaced one side, with tongued-and-grooved edges.
S 1 S	Surfaced one side.
S 1 S 1 E	Surfaced one side and one edge.
S 1 S 2 E	Surfaced one side and two edges.
S 2 S	Surfaced two sides.
S 2 S 1 E	Surfaced two sides and one edge.
S 2 S 2 E	Surfaced two sides and two edges.
S 4 S	Surfaced four sides.
S 4 S C S	Surfaced four sides with 1/16 of an inch calking-seam on each edge.
F A S	Free along side; within reach of ship's tackles.
C I F	Cost, insurance and freight.
C I F E	Cost, insurance, freight and exchange.
K D	Kiln-dried.
G	Green.
M L	Mixed lengths.
C M	Center-matched.
W P	White pine.
Y P	Yellow pine.
Com	Common.
Merch	Merchantable.

length shipments of this grade, 5 per cent of 6 or 7-foot lengths in C, D, and No. 1 Common grade and 5 per cent of 4 or 5-foot lengths in No. 2 Common grade.

The above percentages are allowed in all shipments of mixed lengths even though the number of feet of each length in such shipments be specifically stated.

Grades of Flooring. A, B, C, D, No. 1 Common, No. 2 Common and No. 3 Sheathing, Flat Grain; and A, B, C, D and No. 1 Common, Edge-Grain.

Defects of Flooring. Defects named in flooring are based upon a piece manufactured from a 1 by 4-inch by 12-foot, and pieces larger or smaller than this will take a greater or less number of defects, proportioned to their size on this basis, except that standard knots shall not exceed 1¼ inches in diameter in 3-inch flooring.

A, Flat flooring, must be practically free from defects on the face-side and well manufactured.

B, Flat flooring, will admit any two of the following or their equivalent of combined defects: 15 per cent sap-stain; 15 per cent firm, red heart; three pin-knots; one standard knot; three small pitch-pockets; one standard pitch-pocket; one standard pitch-streak; slight, torn grain; small seasoning-checks; six pin worm-holes.

C, Flat flooring, will admit any two of the following defects or their equivalent of combined defects: 25 per cent of sap-stain; 25 per cent of firm red heart; two standard pitch-streaks; medium, torn grain, or other machine-defects that allow of laying without waste; slight shake that does not go through, or seasoning-checks that do not go through; two standard pitch-pockets; six small pitch-pockets; two standard knots or six pin-knots; twelve pin worm-holes.

Edge-grain flooring shall take the same inspection as flat-grain flooring except as to the angle of the grain.

Heart-face edge-grain shall be free from sap on face-side.

D, Flat flooring, will admit the following defects or their equivalent of combined defects: sound knots not over one-half the cross-section of the piece in the rough at any one point throughout its length; three pith-knots; pitch; pitch-pockets; sap-stain; firm, red heart; seasoning-checks that do not go through; shake that does not go through; a limited number of pin worm-holes, well scattered; loosened or heavy, torn grain, or other machine-defects that allow of laying without waste.

Pieces otherwise as good as B may have one defect (like a knot-hole) that can be cut out by wasting 1½ inches of the length of the piece, provided both pieces will be 16 inches or over in length after such defects are cut out.

No. 1 Common flooring is the combined grade of C and D flooring, and will admit all pieces that will not grade B and are better than No. 2 Common.

No. 2 Common flooring admits all pieces that will not grade as good as D flooring, that can be used for cheap floors without a waste of more than one-fourth the length of any one piece.

No. 3 Sheathing will admit of all pieces that cannot be used as No. 2

Common flooring, but are still available as cheap sheathing or lathing without a waste of more than one-fourth the length of any one piece.

Center-matched flooring shall be required to come up to grade on face side only, and the defects admissible on the reverse side of standard matched shall be allowed.

2. *Oak Flooring Grading Rules.** A. Quarter-sawed Oak Flooring. Red or White Oak. In ordering oak flooring it should be stated whether plain or quarter-sawed red or white oak is desired.

Clear. Shall have one face practically free of defects, except ⅜ of an inch of bright sap; the question of color shall not be considered; lengths in this grade to be 2 feet and up, not to exceed 10 per cent under 4 feet.

Sap-clear. Shall have one face practically free of defects, but will admit unlimited bright sap. The question of color shall not be considered. Lengths in this grade to be 1 foot and up.

Select. May contain bright sap, and will admit pin worm-holes, slight imperfections in dressing, or a small tight knot, not to exceed one to every 3 feet in length; lengths to be 1 foot and up.

B. Plain-sawed Oak Flooring. Clear. Shall have one face practically free from defects, except ⅜ of an inch of bright sap; the question of color shall not be considered; lengths in this grade to be 2 feet and up, not to exceed 10 per cent under 4 feet.

Select. May contain bright sap, and will admit pin worm-holes, slight imperfections in dressing, or a small tight knot, not to exceed one to every 3 feet in length; lengths to be 1 foot and up.

No. 1 Common. Shall be of such nature as will make and lay a sound floor without cutting. Lengths 1 foot and up.

Factory. May contain every character of defects but will lay a serviceable floor with some cutting. Lengths 1 foot and up.

Widths of Pieces for Oak Flooring. The 1½-inch face makes a better, more serviceable and handsomer floor than any other width. The shading of the figure of the wood may be blended more harmoniously than when the wider strips are used. The laying-waste in the $^{13}/_{16}$ by 1½-inch face is less than in the 2-inch face, as it is counted ½ an inch for the tongue-and-groove, whereas in the broader widths, it is counted ¾ of an inch. The cost per thousand feet is less than in the wider widths, which offsets additional cost for labor in laying.

The 2 and 2¼-inch faces are the widths more generally used in $^{13}/_{16}$-inch thickness, and in ⅜-inch thickness either 1½ or 2-inch face, as conditions demand.

Thicknesses of Pieces for Oak Flooring. For widths of 1½- and 2-inch face, ⅜ and $^{13}/_{16}$ of an inch thickness. For a width of 2½-inch face, $^{13}/_{16}$ of an inch thickness.

The Use of Different Grades of Oak for Flooring. Clear, quarter-sawed, red or white: high-class residences, hotels, apartment-houses and club-houses.

Sap-clear, select, quartered, red or white: an economical substitute for the

* From "Oak Flooring," published by The Oak Flooring Manufacturers' Association of the United States, Detroit, Mich.; and "Wilce's Hardwood Flooring-List," published by The T. Wilce Company, Chicago, Ill.

clear, quartered grade, where a dark finish is desired. These grades make as durable a flooring as those of the first grade.

Clear, plain-sawed, red or white: high-class residences, hotels, apartment-houses, churches and club-houses.

Select, plain-sawed, red or white: medium-priced residences, hotels and apartments; schools, office-buildings and stores.

No. 1 Common: cheap dwellings, tenements, stores, high-class factories and manufacturers' buildings.

Factory: warehouses, factories and cheap tenements.

3. *Grading Rules for Various Other Woods Used for Flooring.* The preceding paragraphs illustrate the general rules and methods of grading one of the softwoods and one of the hardwoods used for flooring. For the other woods the reader is referred to the different manufacturers' associations, such, for example, as the Northern Pine Manufacturers of Minneapolis, Minn., for white pine and Norway pine; the Spruce Manufacturers' Association for spruce; the Oregon Lumber Manufacturers' Association of Portland, Ore., the Southwestern Washington Lumber Manufacturers' Association or the Pacific Coast Lumber Manufactureres' Association for Douglas fir, Western spruce, hemlock and red cedar; the T. Wilce Company, of Chicago, Ill., and others for flooring in maple, birch, beech, walnut and cherry; and other associations for other flooring-woods.

324. STANDARD WEIGHTS OF HARD-WOOD FLOORING. For such woods as maple, beech, birch, oak, walnut and cherry the following weights of flooring are given: *

3/8-inch-thick flooring	1000 pounds per 1000 feet.
1/2-inch-thick flooring	1200 pounds per 1000 feet.
5/8-inch-thick flooring	1500 pounds per 1000 feet.
13/16-inch-thick flooring, 1 1/2-inch, 2-inch, and 2 1/4-inch face	2100 pounds per 1000 feet.
13/16-inch-thick flooring, 3 1/4-inch face	2250 pounds per 1000 feet.
1 1/16, 1 5/16 and 1 11/16-inch-thick flooring, 2-inch and 3 1/4-inch face	2500 pounds per 1000 feet.

For oak flooring the following weights are given: †

3/8 by 1 1/2-inch face	1000 pounds per 1000 feet.
3/8 by 2 -inch face	1200 pounds per 1000 feet.
13/16 by 1 1/2-inch face	2000 pounds per 1000 feet.
13/16 by 2 -inch face	2100 pounds per 1000 feet.
13/16 by 2 1/4-inch face	2200 pounds per 1000 feet.

* "Wilce's Hardwood Flooring-List," published by The T. Wilce Company, Chicago, Ill.

† "Oak Flooring," published by The Oak Flooring Manufacturing Association of the United States, Detroit, Mich.

325. AMOUNT OF FLOORING REQUIRED. To find the amount of flooring required to cover a certain space, first figure the number of square feet, that is, the width multiplied by the length. For example, a room 12 feet wide by 15 feet long has 12 times 15 feet or 180 square feet of floor-area. Then add to the number of square feet so found, the following percentages for the different sizes:

Add $16\frac{2}{3}$ per cent for floors laid with $\frac{3}{8}$ by $\frac{7}{8}$-inch boards.
Add $33\frac{1}{3}$ per cent for floors laid with $\frac{3}{8}$ by $1\frac{1}{2}$-inch boards.
Add 25 per cent for floors laid with $\frac{3}{8}$ by 2 -inch boards.
Add $33\frac{1}{3}$ per cent for floors laid with $\frac{1}{2}$ by $1\frac{1}{2}$-inch boards.
Add $37\frac{1}{2}$ per cent for floors laid with $\frac{1}{2}$ by 2 -inch boards.
Add $33\frac{1}{2}$ per cent for floors laid with $\frac{1}{2}$ by $2\frac{1}{2}$-inch boards.
Add $37\frac{1}{2}$ per cent for floors laid with $\frac{5}{8}$ by 2 -inch boards.
Add $33\frac{1}{3}$ per cent for floors laid with $\frac{5}{8}$ by $2\frac{1}{4}$-inch boards.
Add $37\frac{1}{2}$ per cent for floors laid with $\frac{13}{16}$ by 2 -inch boards.
Add $33\frac{1}{3}$ per cent for floors laid with $\frac{13}{16}$ by $2\frac{1}{4}$-inch boards.
Add 25 per cent for floors laid with $\frac{13}{16}$ by $3\frac{1}{4}$-inch boards.
Add 50 per cent for floors laid with $\frac{5}{8}$ by $1\frac{1}{2}$-inch maple.
Add 50 per cent for floors laid with $\frac{13}{16}$ by $1\frac{1}{2}$-inch maple, beech, birch, walnut or cherry.
Add $33\frac{1}{3}$ per cent for floors laid with $\frac{5}{8}$ by $1\frac{1}{2}$-inch oak.
Add $33\frac{1}{3}$ per cent for floors laid with $\frac{13}{16}$ by $1\frac{1}{2}$-inch oak.

These figures presuppose that the flooring is laid straight across the room. When the flooring is laid to form some design, or where there is cutting to fit around hearths or other projections, greater percentages should be added according to the amount of cutting. All bay-windows and other offsets that are to be floored should be figured separately from the main floor.

326. LAYING AND NAILING OF FLOORING. 1. *Laying the Flooring.* In starting to lay the hardwood flooring, it is recommended that a space be left between the first strip and the studding or wall, that can be covered with the base and quarter-round. This space should be left at the ends and the opposite side also, so that in case the flooring swells it will have room to spread without crowding the studding or wall and thus buckling and spoiling the surface. Care should be taken to see that the first strip is laid straight across the room and that each succeeding one is laid in the same manner. If the flooring is not laid straight, it will throw off the end-matching, which is at right-angles, and leave an opening between the ends. To make sure of getting it straight, after three or four courses are laid, one edge of a 4 by 4-inch piece should be placed against the tongue, and the opposite edge hit with

a sledge. This will force each strip to "shoulder-up" tight against the preceding one, and insure an absolutely tight joint and perfect alignment. It should not be forced so tight that it will buckle. The appearance of a floor can be improved very materially if a little care is exercised in not putting together strips that show too great a contrast in color.

2. *Nailing the Flooring.* The nailing is very important and should be given special attention. The $\frac{13}{16}$-inch flooring should be nailed every 16 inches with an eightpenny, cut, flooring-brad, and

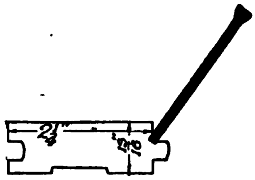


Fig. 562. Eightpenny Cut-Steel Nail for $\frac{13}{16}$-Inch Flooring.

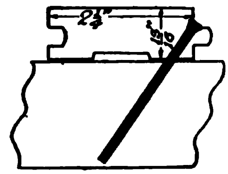


Fig. 563. Nail Shown in Fig. 562. Driven and Set.

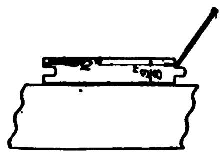


Fig. 564. Threepenny Nail for $\frac{3}{8}$-Inch Flooring.

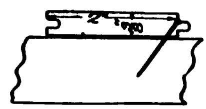


Fig. 565. Nail Shown in Fig. 564, Driven and Set.

the $\frac{3}{8}$-inch-thick flooring should be nailed every 8 or 10 inches with a threepenny finishing-nail. Before the nail is started, the strip should be shouldered-up against the preceding one. The nails should be driven at an angle of 55 degrees. Fig. 562 shows the eightpenny, cut, flooring-brad in the position in which it should be held in starting, and Fig. 563 shows the same nail after it has been driven its entire length, and set. Figs. 564 and 565 show the same positions respectively for the threepenny finishing-nail. If the nail is driven too straight, it will split the tongue, and will not draw the flooring up; and if driven too slanting, it will cause the flooring to buckle. After the nail has been driven almost its entire length, it should be given a final blow with the hammer to set it and to draw the flooring tightly together. It should not be continually tapped with the hammer after it is driven up, as this will work the nail loose again. In setting the nail, care should be taken not to

bruise the face of the flooring, as this will leave an opening between the strips and mar the appearance of the surface.

The sizes of cut-steel nails for different thicknesses of flooring are as follows:

For 13/16-inch thickness, eightpenny nails.
For 7/16-inch thickness, fourpenny nails.
For 3/8-inch thickness, threepenny nails.

The maximum distance between nails for the various thicknesses of flooring should be as follows:

For 13/16-inch thickness, 16 inches.
For 7/16-inch thickness, 12 inches.
For 3/8-inch thickness, 10 inches.

If the nails are driven somewhat closer together than the distances above mentioned, still better results will be obtained.

327. SCRAPING AND SANDPAPERING FLOORING. After the hardwood flooring is laid and thoroughly swept, it is better to scrape it, in order to get the best results for a nicely polished surface. This scraping-process can be done by the ordinary scrapers, such as are used by cabinet-makers, or by one of the many types of power or hand-scraping machines that are generally used by contractors and carpenters. The scraping should always be lengthwise of the wood and not across the grain. A floor properly scraped looks very smooth, but it should be thoroughly gone over with No. 1½ sandpaper to obtain the best results in finishing. After this, the floor should be swept clean, and the dust removed with a soft cloth. The floor is then ready for the finish.

328. PARQUET-FLOORING. Ornamental flooring, other than ordinary hardwood flooring, is now generally divided into two classes: "parquet"-flooring and "parquetry"-flooring. Parquet-flooring is really tongued-and-grooved strip-flooring carefully handled and specially worked until it is practically a cabinet-maker's product rather than the product of a flooring-mill. In most of this parquet-flooring, the tongue-and-groove is in the middle of the edge and a good contact-joint is made both on the upper and lower face between each strip and its neighbor. This prevents the tendency, common in ordinary tongued-and-grooved flooring-strips, to push up at the joints during damp weather, if the bevel is formed by the undercutting on the edge. The undercut on ordinary tongued-and-grooved flooring is made partly to enable the carpenter to lay the boards more easily and quickly; also to prevent warping.

This parquet-flooring is also made so exactly to size that it can be used in various patterns by cutting into shorts and double-grooving, or tongue-and-grooving, the ends. The patterns most used are similar to the designs shown in Figs. 566, 567 and 568 and those of the "wood-carpet" square, shown in Fig. 570. In most

Fig. 566. Hardwood Floors in Patterns.

of these patterns the two ends of the pieces are grooved and slip-tongues are used. Each short strip is nailed independently in the same manner as is the ordinary tongued-and-grooved flooring.

Fig. 567. Hardwood Floors in Patterns and "Herring-Bone" Effects.

Much of this parquet-flooring in long strips, or in patterns, such as squares, rhombs, herring-bones, etc., is made of various fancy-colored and figured woods, either solid or veneered onto a pine or chestnut backing. Most of the fine old floors in Europe were made of this parquet-flooring and such floors are duplicated in the United States with great frequency.

Both parquetry and parquet-flooring, after being laid, must be thoroughly scraped. Very little planing is done since the invention

of the veneer-scraper. Floors must be veneer-scraped, touched up here and there with a small cabinet-scraper, and smoothed with No. 1 sandpaper. Opinions vary as to the proper method of finishing. Thin parquetry-flooring is usually filled, after the holes made by the countersunk nail-heads have been puttied, and the floor finished either in varnish, shellac, or, best of all, shellac and wax. Thick floors are sometimes filled and then finished in shellac and wax and sometimes simply finished in shellac and wax. Occasionally nothing but wax is used.

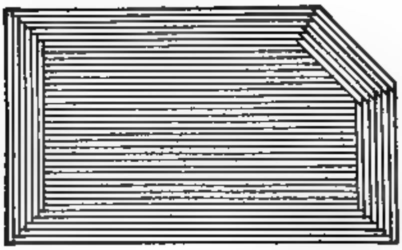


Fig. 568. Hardwood Floors with Border-Effects.

Both thin parquetry and parquet-flooring are manufactured in several good factories in this country. The price varies slightly with the quality of work in the different plants. All these manufacturers supply books of instruction on laying and finishing according to the most up-to-date methods. It is most important in the manufacture of ornamental hardwood flooring that the lumber be well seasoned and thoroughly kiln-dried. After that it is necessary that it be kept in tight, heated, storerooms, until the moment of shipment and then rushed to the job as quickly as possible. Heat should be in the building before the flooring is laid. The flooring should be the last thing installed. The trim should be set and the plastering and papering completed before the floors are laid.

The largest manufacturers of parquetry, or wood mosaic, and parquet-flooring have floor-laying agencies in most of the large and many of the small cities in the United States and Canada. These agencies are thoroughly up-to-date in methods of finishing. They have at their disposal for reference, the manufacturers' collections of design-books and photographs of famous installations

abroad and at home, and are equipped to do special work in collaboration with the architect and decorator.

329. PARQUET-FLOORING FOR FIRE-PROOF BUILDINGS. The modern demand for buildings of fire-proof construction has brought forth many fire-proof floors. The objection to some of them, however, is that they are more or less noisy, or uncomfortable to walk or stand upon. No flooring-material has taken the place of wood for comfort and artistic effects, whatever may be said against it as a non-fire-resisting material. Steel-woven flooring * has been invented to be applied to the concrete subfloor so that it will not be part of the construction of the building any more than are the chairs, desks and other furniture. It is some-

Fig. 569. Parquet-Flooring for Fire-Proof Buildings.

times stated that this steel-woven flooring is not attached to the concrete and this is virtually true. Two wall-strips (see Fig. 569) are lightly attached to the concrete by means of a few short pieces of wood, 8 inches long, let into the subfloor. From the inside edge of the second strip, 4-inch square blocks, $\frac{13}{16}$ of an inch or $1\frac{1}{8}$ inches in thickness, are woven by means of steel bands into a gigantic mat which lies of its own weight on the floor. One advantage of this construction is that it results in a sort of air cushion which makes the floor almost noiseless to walk upon. The principal advantage, however, is that when exposed to extremely damp weather or accidental flooding, this floor can swell as a whole and the expansion be taken up by a compression-strip between the two wall-strips; and that when it dries out again the blocks shrink individually, forming only hair-line cracks, which are not noticeable, around each block. This steel-woven parquet-flooring is generally made from quartered white oak, but it is sometimes composed of teak or other hardwoods of different colors. The grain is reversed on each alternate

* Made by the Wood-Mosaic Flooring and Lumber Company, Rochester, N. Y.

block. This floor is finished as are other parquetry-floors and instructions for handling them are issued by the manufacturers.

The great fire which destroyed a large part of the business section in Baltimore was fought from the city court-house. Six lines of hose were laid through the Baltimore Bar library, which was floored with this steel-woven parquet-flooring. For many hours the floor was flooded. About six months after the fire the floor was merely refinished and is in as good condition as when it was laid.

330. PARQUETRY-FLOORING. 1. *Definition.* Parquetry, sometimes known as "wood mosaic," includes parquetry-strips, "wood carpet" and the so-called "parquetry."

2. *Parquetry-Strips.* These are 5/16 of an inch in thickness with jointed square edges and vary in width, the stock sizes being usually 1 1/32, 1 1/2 and 2 inches. They are made in many different hardwoods of different colors, but probably 90 per cent of the parquetry-strips used are quartered white oak. They are of random lengths, from about 4 feet up. Joints are broken on the floor and the strips are squeezed up very tightly and face-nailed about every 4 inches.

3. *Wood Carpet.* This is made from short pieces of parquetry-strips squeezed together on a frame or table, and with cloth glued to the back. After being trimmed on the ends, it is shipped either in rolls or in slabs about 2 feet wide. In slab-form the carpet can be better protected in shipping and more conveniently handled. Wood-carpet is largely used in bedrooms, laid in panel-effect, and in hallways. A very handsome floor (see central part of Fig. 570) can be made of squares cut from this wood carpet. This is probably the favorite parquetry-field design. Other shaped sections, such as rhombs or hexagons, etc., are cut from the same wood carpet.

Fig. 570. "Wood Carpet."

4. *Fancy Parquetry.* This is made of 5/16-inch strips and small blocks of hardwood glued together at the edges to form patterns and backed either by canvas or very thin veneer. Different colored woods are very frequently used to pick out the patterns (see border in Fig. 570). These borders usually vary from 6 inches to 24 inches in width and are 12 feet in length. Fancy-parquetry fields are also made of 5/16-inch small blocks glued together in patterns. Some designs are all of one wood, usually quartered oak,

and depend for the pattern on the change of direction of the grain. Many different colored natural woods are used in other patterns. These fancy parquetry or wood-mosaic fields are usually made up of 12-inch widths and 4-feet lengths. Fancy-parquetry fields and borders are sometimes made 13/16 of an inch thick by laying veneer on a panel-backing. The edges of the panels are grooved and the floor blind-nailed through slip-tongues.

5. *Cost.* The cost of parquetry-flooring varies with the elaborateness of the design, or pattern, and the expensiveness of the woods used. The prices range from about 8 cents for parquetry-strips to 10 to 15 cents for wood-carpet squares and from 15 to 25 cents per square foot for thin, fancy parquetry. The veneering to a 13/16-inch total thickness adds from 12 to 15 cents per square foot. These prices do not include the expense of laying.

6. *Laying.* Thin parquetry is best laid over a double floor but is usually laid on top of a single floor. Formerly sometimes only a border was provided and the center left depressed for a rug. This method is rarely followed now, owing to the fact that nearly every one wants a hardwood floor for sanitary reasons if for no other and a depression to gather dust, etc., defeats this purpose. Small rugs, also, are used more frequently than large ones and the cost of a large border is very little less than that of a whole floor, owing to the fact that most of the labor is involved in fitting the outside of the room. Thin parquetry is secured to the subfloor by 1¼-inch wire brads if the underfloor is of softwood, or by 1-inch brads if of hardwood. The brads are driven through the top and countersunk for puttying. From 20 to 40 brads to the square foot are generally used.

7. *Subfloors for Parquetry.* Narrow matched pine boards, well dried out and well nailed, make the best underfloor. In old residences such a foundation cannot always be had. Many floors are laid over as inferior a subfloor as hemlock. It pays, however, to have a good matched subfloor of thoroughly dry material. The parquetry-floor then stands better and is much more satisfactory in every way. Subfloors should run diagonally, if possible. In no case should the parquetry be laid parallel with the subfloor. Foundation-floors must be made true and level by traversing, as inequalities in the foundation will cause a great deal of extra scraping on the parquetry and the job will never be as good.

8. *Paper between Floors.* A thickness of good sheathing-paper, preferably water-proof, should be evenly laid over the subfloor and the parquetry laid on top.

9. *Dry Material and Warm Rooms.* If thin parquetry-floors are not to open at the joints, it is essential that the material be

thoroughly dry when laid. The floor will stand much better if there is heat in the house. It is absolutely necessary, if a good job is required, that a new house be heated for a few weeks before the flooring is put down.

15. SUPERINTENDENCE OF INTERIOR WOODWORK.

331. SUPERINTENDENCE OF INTERIOR WOODWORK. 1. *Importance of Careful Inspection.* Although the interior finish of a building is not of such vital importance as the constructive portion, yet the impression which a building makes upon the owner, or the occupants, is largely determined by the character of the finish and the care exercised over minor details. The architect or his superintendent should give as much care to the inspection of the finish as to any other portion of the work, and should especially look after all the little things to see that they have not been overlooked by the workmen, or improperly done. The young architect should remember that every defect, whether in material or workmanship, is quite sure to be discovered in time, and may reflect seriously upon the person whose business it was to look out for and correct it.

2. *Inspection of Stock.* As soon as the stock for the interior work is delivered at the building it should be closely examined for defects, such as sap, knots or pitch, and any defective pieces should be marked in such a way that there will be no chance of their being used. If the superintendent has not entire confidence in the work of the contractor, he should endeavor to ascertain personally if the finish has been dried as required by the specifications, or test it as described in Art. 15.

3. *Inspection of Doors.* The doors will of course be made at the shop, and as it is not always possible to tell from the appearance of the completed door whether or not it has been made according to the specifications, a written guarantee should be required for all hardwood doors. By examining the edges of a veneered door, the thickness of the veneer can be seen. The ends of the doors will also generally show how the stiles have been glued up.

4. *Smoothing Up.* After the stock for the joiners' work has been inspected it should be carefully smoothed up by hand, unless this has been done by special machinery at the mill (see Art. 236), and the superintendent should see that this work is thoroughly done.

5. *Comparing Work with Detail Drawings.* All moldings, panel-work, etc., should be carefully compared with the detail drawings to see that the latter have been carefully followed, and that the door-frames are placed so that the doors will swing as

shown on the plans. It often happens that it is advisable to swing a door in a different direction from that indicated on the plan, owing to a register-opening or radiator coming in the way. In such cases the superintendent should consult with the architect regarding the proper change to be made before the frame is set.

The superintendent should also take pains to see that the details for the fittings, etc., will work out properly to fit their allotted place in the building, and that all changes are made that may be required on account of alterations from the original plans.

6. *Testing Door-Frames.* Door-frames should be tested to see that the jambs are plumb and the heads level. A frame is often set so that the head is not square with the jambs. Such unsightly work should be guarded against. The superintendent should caution the foreman of the joiners to have the nails driven in the quirks of the moldings, whenever possible, in putting up the finish.

7. *Spliced and Crooked Moldings, Loose Sash, etc.* If the casings or architraves for the doors and windows are sent to the building in random lengths, the superintendent should be watchful to see that the carpenter does not undertake to splice them (see Art. 250), and it will be well to caution the foreman beforehand that this must not be done. Horizontal finish, such as bases, chair-rails, cornices and picture-moldings, must occasionally be spliced, and in such cases the superintendent should see that the adjoining pieces are properly matched and jointed. Another matter that should be carefully watched is the putting up of the chair-rails and picture-moldings. The joiner often puts these up "by his eye," which is sometimes not very true, so that when the walls are papered or decorated it will be found that the moldings are far from level, and the fact will be made conspicuous by the frieze or pattern of the paper or decoration. The superintendent should test all such moldings by measuring from the floor or ceiling, or by a spirit-level. Before the house is turned over to the painter the superintendent should try all the doors and windows to see that the former swing and shut properly, and that the latter move easily up and down without being loose enough to rattle and that the sash are properly balanced and hung with the proper cord or ribbon. If any are found that do not work properly he should see that they are fixed before the painters or finishers commence work.

8. *Inspecting Stair-Work.* The erection of the stairs should be carefully watched to see that they are put up in accordance with the specifications and in a workmanlike manner. If they are built by the Boston method (see Art. 299) the carriages should be examined to make sure that they are so placed that the treads will be perfectly level and the risers all of the same height. The work-

men sometimes make mistakes in cutting the carriages, and then try to make them answer by tipping them slightly or by adding to the upper and lower risers if they are too short, or by cutting a little off these risers if the carriages are too long. Such misfits should be carefully watched for and condemned immediately on detection. The cost of a new set of carriages is insignificant compared to the harm done to the stairs. When built by the English method the wedging and blocking up of the finish-work from the carriages should be carefully looked after.

9. *Comparing Work with Specifications.* As the work draws toward completion the superintendent should carefully read the specifications, make notes of everything that has not been done, or that he is not sure has been done properly, and have any work that is not properly put up corrected.

CHAPTER VI.

Builders' Hardware.*

1. ROUGH HARDWARE.

332. CLASSIFICATION. Although it is practically impossible for the architect to keep posted on all that the market contains in the way of "builders' hardware," it is necessary that he be familiar with the kinds and qualities of hardware in common use, so that he may be able to specify or select such hardware as is best adapted to his purpose and to distinguish between the different qualities. Builders' hardware may be divided into two classes, rough hardware and finished hardware. The latter is usually designated "shelf hardware" or "trimmings."

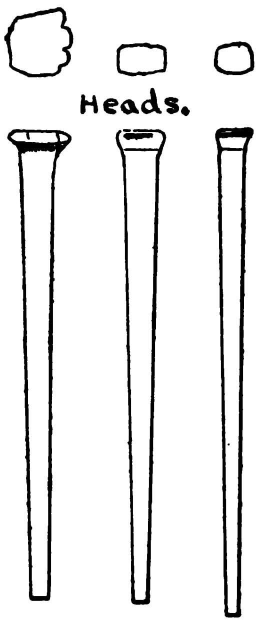


Fig. 571. Cut Nails, 8d Size.

333. PRINCIPAL KINDS OF ROUGH HARDWARE. The principal forms of hardware in this class comes under the head of nails, screws and bolts.

334. NAILS. Based upon the process of manufacture there are three kinds of nails in common use, namely, plate or cut nails, wire nails, and clinch-nails. These are briefly described in the following subdivisions of this article and other data bearing on the subject is included.

* Much valuable data for the revision of this chapter was furnished by the following firms: The Yale & Towne Manufacturing Company, New York City; Sargent & Company, New Haven, Conn.; the Russell & Erwin Manufacturing Company, New Britain, Conn.; P. & F. Corbin, New Britain, Conn.; The Stanley Works, New Britain, Conn.; The Richards-Wilcox Manufacturing Company, Aurora, Ill.; Bommer Brothers, Brooklyn, N. Y.; The Chicago Spring Butt Company, Chicago, Ill. In addition to these firms, many representatives of the manufacturers of hardware specialties have furnished new and revised matter.

1. *Cut Nails.* Cut nails are made from a strip of rolled iron or steel of the same thickness as the finished nail and a little wider than its length, the fiber of the iron being parallel with the length of the nail. Special machinery cuts the nails out in alternate wedge-shaped slices, the heads are then stamped on them and the finished nails dropped into the casks. Cut nails made from iron are generally preferred for use in exposed positions.

Cut nails are made in a variety of shapes to suit special uses. For ordinary use in building, nails of three different shapes are made, and the nails are called "common nails," "finish-nails" and "casing-nails." Fig. 571 gives the exact size and shape of an eighfpenny nail of each kind. The common nails are used for rough work, finish-nails for finished work, and casing-nails for flooring, matched ceiling and sometimes for pine casings, although the heads are rather too large for finish-work. Cut nails are beginning to return to favor as they have holding-power and lasting-qualities superior to wire nails.

2. *Brads.* Brads are thin nails with a small head, used for small finish, panel-moldings, etc. They vary from 1/4 of an inch to 2 inches in length.

3. *Clout-Nails.* Clout-nails are made with broad, flat heads, and are sold in sizes varying from 3/8 to 2 1/2 inches in length. They are used chiefly for fastening gutters and metal-work.

Special nails are also made for lathing, slating, shingling, etc.

4. *Wire Nails.* These have of late years become as common as the cut nails, and are sold at about the same price. They are said to be stronger for driving than the cut nails, not so liable to bend or break, especially when driven into hard woods, and less liable to split the wood; for these reasons they are generally perferred by carpenters.

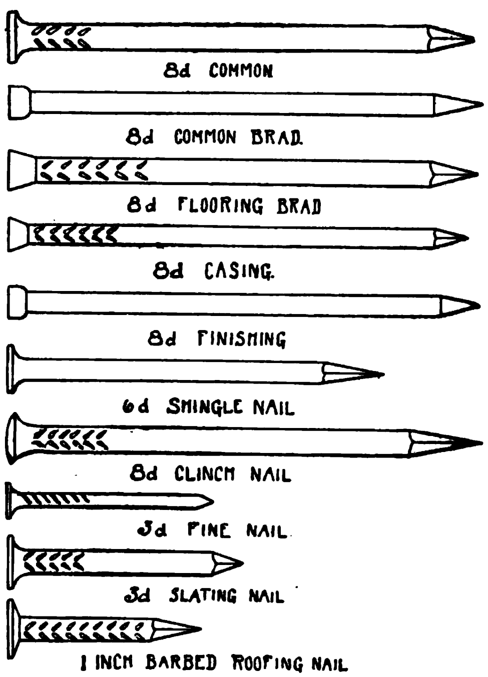


Fig. 572. Wire Nails, (Full Size).

Wire nails are made from wire of the same section-diameter as the shank of the nail, by a machine which cuts the wire in even lengths, heads and points them, and, when desired, also barbs them. Fig. 572 gives full-size illustrations of the various types of wire nails in common use. In general the same classification is used for cut nails. It should be noticed that the

gauge of the wire and the shape of the head varies in the different kinds, and that some are barbed, others plain. The various types of wire nails are drawn "round," "smooth" or "barbed," for the domestic trade; for export they are drawn "oval," "square," or "diamond-shaped," according to the country to which they are to be shipped and the requirements of that country. It is customary to charge 15 cents more per 100 pounds for standard nails, "barbed," than for the same nails "smooth."

5. *Clinch-Nails.* These are made from open-hearth or Bessemer-steel wire. Any ordinary wire nail will clinch, especially when made with "duck-bill" or flattened points for clinching purposes, or even otherwise, if annealed. These nails are used only in places where it is desired to turn over the ends of the nails to form a clinch, as in the case of battens or cleats.

6. *Lengths and Weights of Nails.* The length of nails is designated by "pennies" (ds). This classification originally represented the price in English pence per 100 nails, as 2d per 100, etc. In that sense it is of course now obsolete, but it is still retained and is practically uniform with the various manufacturers, both for cut and wire nails. The weights run from two-pennies to sixtypennies, with the lengths given in the following table, the gauge-number being for wire nails:

TABLE X.

Names, Lengths and Gauges of Nails, with Number to the Pound.

Name.	Length in inches.	Gauge.	Number to the pound.*
2d	1	15	876
3d, fine	1¼	15½	600
3d, common	1¼	14	568
4d	1½	12½	316
5d	1¾	12½	271
6d	2	11½	181
7d	2¼	11½	161
8d	2½	10¼	106
9d	2¾	10¼	96
10d	3	9	69
12d	3¼	9	63
16d	3½	8	49
20d	4	6	31
30d	4½	5	24
40d	5	4	18
50d	5½	3	14
60d	6	2	11

The length of the various kinds of nails illustrated is the same for the corresponding "penny," but the gauge-number varies slightly.

7. *Sizes of Nails for Different Classes of Work.* Contractors who value their reputation may be relied upon to use nails of proper size; but unfortunately there are many builders who, for the sake of saving a few cents, will use smaller nails than the work demands, and to insure against this it is well in certain classes of work to specify the sizes which are to be used.

* These quantities vary slightly with different manufacturers. The table was revised from data furnished by the American Steel & Wire Company, New York City.

appearance than nails, have greater holding-power and are less apt to injure the material if it should be removed and replaced. By making holes for the screws with a bit, all danger of splitting the finish is averted. The ordinary type of screw has a gimlet-point by which it can be turned into the wood without the aid of a bit. The heads are made in various forms to suit different uses. Fifteen types are shown in Figs. 573 and 574, including one form of headless screw and one dowel-screw.

Screws are made ordinarily of steel, but sometimes of brass and

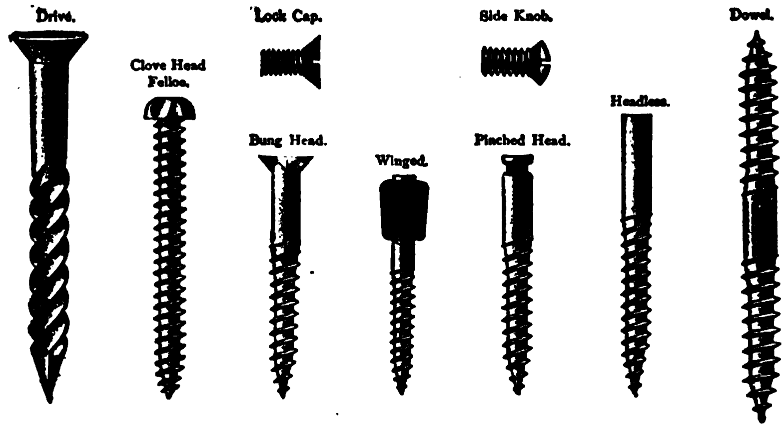


Fig. 574. Various Types of Screws

bronze. The latter sort are used for screwing in place finished hardware of the same material, and have heads finished to correspond with the trimmings. Steel screws, also, are finished with blue, bronze, lacquered, galvanized, or tinned surface, to match the cheaper class of trimmings. The galvanized finish is used in building operations at the seashore. Screws with blue surface, called "blued screws," are generally used with japanned hardware and for stop-beads, and wherever a cheap round-headed screw is desired. Silver, nickel, and gold-plated screws are also manufactured for use in connection with similar hardware. Steel screws for wood are made in twenty different lengths, varying from ¼ of an inch to 6 inches, and each length of screw has from six to eighteen varieties in thickness, there being in all thirty-one different gauges; so that altogether there are in market about two hundred and fifty different sizes of ordinary screws used for woodwork.

In ordering screws both the length and number of the gauge or diameter of the shank, the material and finish, and the use to which

they are to be put, should be given. Fig. 575 gives the exact section of each gauge of American screws.

Fig. 574 * shows a patent screw which has a diamond point. This allows it to be driven with a hammer its entire length into any hard wood, and then held by one or two turns as securely as the ordinary screw.

Besides the ordinary wood-screws there are lag-screws and hand-rail screws or joint-bolts, both of which are much used by builders. Hand-rail screws are illustrated in Fig. 536, Chapter V. Lag-screws and fetter-drive lag-bolts, which are used only in wood, have a conical point (Fig. 576), deep threads and a square head, like that of an ordinary bolt; they are turned by a wrench. They are made from 5/16 of an inch to 1 inch in diameter and from 1½ to 12 inches long. Lag-screws larger than ½ an inch are seldom gimlet-pointed as a hole is usually bored for them before they are inserted. In framing they are often used instead of bolts.

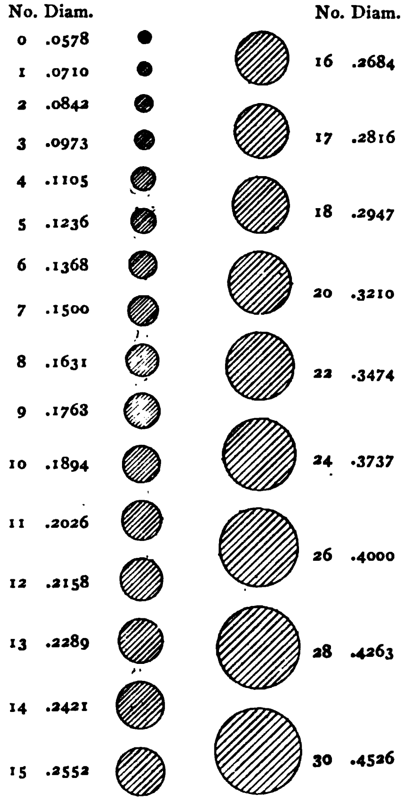


Fig. 575. American Screw-Gauge

Coach-screws are similar to lag-screws, except that they have a gimlet-point. They are not usually made over ¾ of an inch in diameter, although some manufacturers list a ⅞-inch variety.

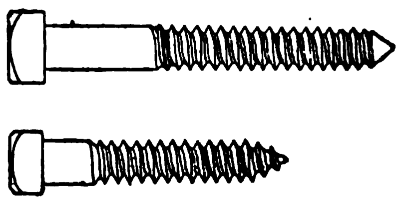


Fig. 576. Lag and Coach-Screws.

336. BOLTS. About the only shape of bolt used by builders is the common round

* Manufactured by the Russell & Erwin Manufacturing Company, New Britain, Conn. The American Screw Company, Providence, R. I., and several other manufacturers also make drive-screws. The drive-screw is shown at the left, in Fig. 574.

bolt with square head and nut. Bolts up to 24 inches in length and 1½ inches in diameter are generally carried in stock by the larger hardware-dealers; above that size they are usually made to order. Button-head bolts, Fig. 577, either round or square under the head, are used in wood. They are carried in stock in sizes from ¼ to ¾ of an inch in diameter, and from 4 to 12 inches long; they are sometimes preferable to the ordinary square-head bolts. The square shoulder serves somewhat in the nature of a lock, and holds the bolt rigid while the nut is being screwed on. Throughout the West builders use large quantities of ½-inch carriage-bolts, from 4 to 12 inches in length. When a larger size is required, machine-bolts with square heads are generally used.

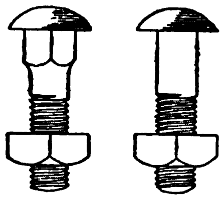


Fig. 577. Button-Head Bolts.

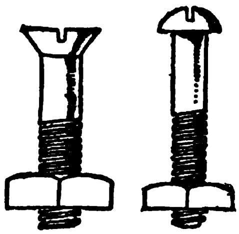


Fig. 578. Stove-Bolts.

Stove-bolts are sometimes used in building-operations. They are made with flat and round heads, as shown in Fig. 578, and in sizes varying from ⅜ of an inch to 6½ inches in length and from 5/32 to ½ of an inch in diameter.

Many bolts, especially the smaller, are now made with what is called the "rolled thread." This type is made from scant material. The threads are rolled between dies to the full diameter of the threaded portion, whereas the body of the bolt is slightly scant.

2. FINISHED HARDWARE.

337. MATERIALS AND FINISH OF HARDWARE. Most of the finished hardware used about buildings is made of steel, wrought iron, brass or bronze. For the very cheapest work cast iron is used to a limited extent.

338. CAST-IRON AND STEEL HARDWARE. Nearly all of the cheaper grades of butts, locks, etc., are made of cast iron or steel. Very few cast-iron knobs are now used. This material answers very well as far as durability is concerned; the principal objection to it is its liability to break under a blow or jar. For this reason it is not suitable for bolts or their casings, although it is often used in the cheaper work. Although heavy cast iron will outwear steel, it is not well suited for butts, as it often breaks from an unequal stress or sudden jar.

339. FINISH OF IRON AND STEEL HARDWARE.

There is a great variety of finishes for iron and steel hardware. For the very cheapest class of work the iron or steel is left just as it comes from the foundry, except for a little cleaning with the file or brush. The cheapest finish is obtained by coating the surface with japan or bronzing-varnish, the quality of which depends upon the grade of the goods. Japanning is practically indestructible if the metal is not exposed to scratches or rubbing, and for durability is to be preferred to any of the lacquers or imitation-bronzes.

"Berlin bronze," "Tucker bronze," the so-called "Boston finish" and nearly all lacquered hardware is finished by heating the metal and immersing it in a bath composed of linseed-oil and gum-anime or copal, to which are added powdered alloys of copper and bronze to give the desired color. When the coating thus obtained is dry the metal is roasted in a kiln. This seems to dry the preparation into the pores of the metal and leaves it with a smooth, shining surface, that imitates, more or less closely, dull bronze. Hardware treated in this way cannot be polished afterwards; consequently all polishing of the metal is done before the lacquer is applied. In recent years the better grade of iron or steel hardware has been finished by electroplating as described in the next article.

340. PLATED-IRON AND STEEL HARDWARE. These finishes are made in various colors to imitate genuine brass or bronze metal and are often so well done, especially on steel hardware, as to be readily mistaken, even by experts, for genuine brass or bronze. This electroplating is a thin surface-coating of copper, bronze-metal, brass or nickel, the thickness of which depends upon the strength of the solution and the time of immersion. In the factories of the large hardware-manufacturers the process has been so highly developed that a good product with a heavy coating is secured at a low cost.

Nickel-plated iron hardware may also be obtained. This finish, however, is unsuited for nice work, as the nickel will tarnish by exposure to the atmosphere, and no amount of rubbing will restore it to its original appearance.

As a rule, plated hardware is not desirable, except in positions not subject to wear, as the plating will wear off in a short time and expose the black iron beneath. Again, bronze-plating and oxidizing is generally used on very inferior grades of cast-iron hardware, particularly for door-knobs, butts, drawer-pulls, etc., to give the uninitiated the idea that he is purchasing a good article, when in fact it may be a very inferior one.

In specifying plated hardware, therefore, the architect should

confine his choice to those articles that are not subject to wear and of which the base is known to be of good quality. Plated hardware should not be used where it will be exposed to the weather.

341. BOWER-BARFF AND SIMILAR FINISHES. The most appropriate finishes for iron hardware are those obtained by the Bower-Barff or similar processes, which convert the surface into magnetic oxide of iron by means of heat and superheated steam, in which condition it is nearly rust-proof, although it will rust in time if exposed to the weather in a damp climate. The color of the iron when polished is a lustrous ebony-black, especially appropriate for offices and public buildings and some portions of fine dwellings. All ornamental wrought-iron hardware should be finished in this way. The word "wrought" is commonly used in the trade to designate "stamped" steel which is made to appear like the hand-wrought work of the blacksmith. The regular Bower-Barff process is quite expensive, and many other processes are now used to obtain the same result. Bower-Barffed lock-sets are furnished usually with polished-brass front locks and, in the case of cylinder-locks, with polished-brass cylinders.

A good deal of dead-black hardware is finished over bronze. While this looks well at first, the finish wears off after a time so that the bronze shows through. Lock-fronts are usually made in this way, for if cast iron is used the fronts are easily broken. This finish is generally satisfactory except on knobs and handles or other parts subject to constant wear.

342. BRASS HARDWARE. The terms "brass" and "bronze" are often confounded in speaking of hardware, although the materials are quite different in composition and, usually, in appearance. Brass is an alloy of copper and zinc, while bronze is a composition of copper and tin. Brass has a bright yellowish appearance, and is susceptible of a high polish. It tarnishes very easily and is therefore generally protected by a coat of lacquer. This, however, will not entirely prevent it from changing in color. The use of brass for hardware has increased very largely of late years, especially for door-knobs, hinges, bolts, and all kinds of finishing-hardware usually finished in the natural color of the metal. Bright or buffed natural-color brass, and various surface-finishes on brass, are very popular. It is particularly suitable for the colonial type of residence. In buildings of every style oxidized-brass finishes, in various colors and shadings, are very frequently used. In fact about fifty per cent of design-hardware is finished in some form of brass finish. Brass knobs require more labor than bronze to be kept looking well.

343. BRONZE HARDWARE. Bronze is used oftener than any other metal in the manufacture of the better quality of finished hardware. It can be cast with great ease in the most delicate patterns, and may be finished in a great variety of styles and colors.

The general method of producing the different colors of bronze hardware is as follows: the casting, after being "trimmed" or "chased" as may be necessary, is thoroughly cleaned by immersion in a strong acid-bath, followed by one in a weak alkali and clear water. It is then suspended in a bath of hot acids, especially prepared with various chemicals to produce certain changes in the color of the metal. When the desired shade is reached the casting is removed, dried in sawdust and rubbed down to an even tone on a buffing-wheel. Almost any color or shade can be had with bronze by proper treatment.

The colors thus obtained, however, should not be considered as permanent, as they are merely laid on the surface. Copper, silver, gold, nickel and various oxidized finishes are obtained by plating either bronze-metal or iron or steel that has first been plated with bronze or copper. "Bronze hardware is sure to change in time, no matter how it may be finished, and generally the stronger tones are the least satisfactory in the end, for they fade out to unpleasant musty hues." For plain, smooth hardware the natural color of the bronze will prove the most satisfactory in the end, as it can always be kept bright by polishing.

The various finishes given to solid, or bronze-plated hardware, differ more or less in color and appearance with different manufacturers, and the manner of designating them also differs. They also vary in relative cost, somewhat in the following order. Plain bronze being usually the cheapest is taken as the standard, and a fixed charge is added for the other finishes, according to the size of the article. The brackets indicate the same price:

Light bronze.
Brass, natural.

Dark bronze.
Copper, red antique.
Old brass, plain.
Dead black, electroplate.
Nickel.
Old brass.
Dull brass.
Oxidized or antique copper.

Verde-antique.

Silver, light, mottled or dark.

Gold, yellow, red or green tints.

Both bronze-metal and bronze-plated-iron goods are made "plain" and "figured." In the cheaper grades of goods the figured

or ornamented hardware, particularly door-knobs, was formerly thought to be a little cheaper than that with plain surfaces, and the author's experience has been that in a cheap grade the figured knobs show wear less than the plain knobs. In the better grades of hardware ornamentation adds to the price, although, if the ornamentation is artistically designed, not in proportion to the improved appearance. This is also true of the cheaper grades in which there is now a great variety of ornamentation, particularly in wrought steel, bronze and brass.

Eclipse-Metal ("E. M.") * is a hard white metal which has the appearance of highly polished nickel-plate, but since it is of uniform composition throughout, wear will not change its color. When cleaned or polished it retains its color and brightness. This finish is especially suitable for bath-rooms, toilets, lavatories, etc.

The various hardware-manufacturers make many kinds of finishes which are described in their catalogues.

344. SPECIAL HARDWARE-TRIMMINGS. To describe all the special kinds of finished hardware used, or designed to be used, in buildings would be an almost endless task; therefore, only a description of such pieces as are in common use will be attempted.

For most architects a careful perusal of the following pages, supplemented by the manufacturers' catalogues and an examination of the different styles and patterns at the local hardware-dealers, will furnish all the information usually required. The most valuable information, however, can be obtained only by studying the mechanism of the different styles and observing the way in which they wear. When satisfactory hardware has once been found it will be better to keep to that than to experiment with other makes, although the best grades of any of the leading manufacturers may be relied upon.

In describing the various pieces of hardware the author has deemed it best to take them up in the order in which they are related to the different parts of the building.

345. HARDWARE TRIMMINGS FOR DOORS. The hardware for a single door consists usually of hinges, lock, knobs and escutcheon-plates. Outside doors used by the public are also often provided with an overhead check. Double doors require in addition bolts for the standing leaf. Sliding doors are commonly hung on "hangers," and are fitted with lock, flush-pull and cup escutcheon-plates, although very often the lock is omitted. Double-action doors should have push-plates and kick-plates instead of knobs, and a dead-lock if a lock is necessary. Store-doors usually

* Manufactured by the H. B. Ives Company, New Haven, Conn.

have handles instead of knobs, and long escutcheon-plates. Doors that are provided with an overhead check are often fitted with a pull-handle on the inside, a push-plate on the outside, and a dead-lock. A door-pull * is manufactured which is novel in that it is cast hollow, but it is very strong as the metal is 1/8 of an inch thick.

At present a very popular trim for the front doors of residences, particularly the better grade of colonial houses, is the sectional handle. This consists of a handle and thumb-latch with a cylinder key-escutcheon, and a knob on the inside with an elongated escutcheon. The lock used is similar to a store-door lock with stops for dead-locking the latch so that when desired it can be operated from the outside by the key only.

Other trimmings may also be required for special conditions, but the above covers the trimmings commonly used. Each of the above kinds of hardware is made in a great variety of patterns and sizes, the more common of which will be briefly described.

346. HINGES AND BUTTS. Hinges proper are divided into two general classes by the hardware-trade: first, those that are screwed to the face of the door or shutter, and called "hinges," and secondly, those which are screwed to the butt-edge of the door and against the frame, and designated "butts." The latter are almost invariably used for hanging the doors in all but inferior buildings. Hinges are used principally on stable and out-house doors, blinds, shutters, trap-doors, and the like.

Spring-hinges may also be divided in the same way into spring-hinges proper and spring-butts, although the latter are very commonly called "hinges."

347. WROUGHT STRAP AND T HINGES. Hinges proper, used for hanging doors are made exclusively of wrought metal, usually iron or steel, and in two general shapes, namely, those

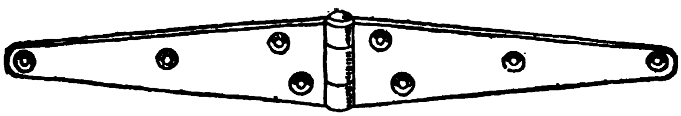


Fig. 579. Strap-Hinge.

shown in Figs. 579 and 580. For doors hung in a frame it is generally necessary to use the T hinge on account of the narrow edge of the frame. Where there is room to use the strap-hinge, as for trap-doors, it should be preferred.

Strap-hinges and T hinges are made in sizes varying by inches from 3 to 16 for the length of each leaf of the strap-hinge, or of

* Manufactured by Sargent & Company, New Haven, Conn.

the long leaf of the T hinge. A 6-inch hinge is the smallest that should be used for a full-size door. They may be obtained in the plain iron, japanned or galvanized, with brass pins. Wrought hinges cannot be broken without first bending and tearing the iron; and where strength and resistance to rough usage are alone desired

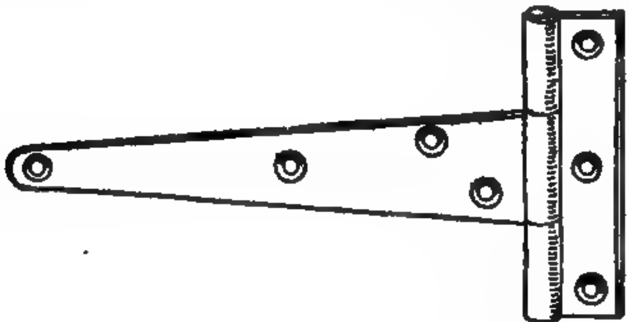


Fig. 580. T Hinge.

they are preferable to butts. They are generally used on battened doors or thin doors where a butt-hinge cannot well be used.

Besides the common strap-hinge and T hinge, shown in Figs. 579 and 580, a patent hinge, "Hart's Patent," is made, which has two thicknesses of steel surrounding the pin, as shown in Fig. 581.* It

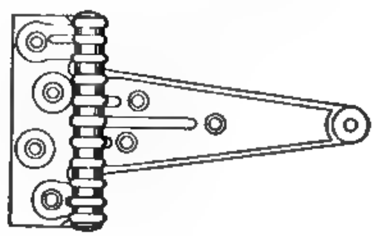


Fig. 581. Hart's Patent Hinge. Fig. 582. Stanley Corrugated Hinge.

is claimed that this hinge has double the strength of the ordinary hinge. The same company makes a corrugated hinge (Fig. 582*) in which the metal is corrugated about the pin and also on the straps and around the screw-holes. By this means the strength of the hinge is greatly increased and the metal is prevented from binding upon the pin. These hinges are made of plain steel, and with japanned, galvanized or bronzed finish, and also of wrought brass. They cost a little more than the cheapest wrought hinges and about the same as heavy plain hinges. The company also

* Manufactured by the Stanley Works, New Britain, Conn.

makes a hinge which may be used on both storm-doors and screen-doors, the same hook or pin remaining upon the door-frame all the

Fig. 583. Construction and Application of the Soss Invisible Hinge.

year round and being used to hang either the storm-door in winter or the screen-door in summer.

This company * also makes several patterns of ornamental hinges and butts in both plated and polished wrought steel and in wrought brass, one pattern of which is shown in Fig. 585. These hinges have a very ornamental appearance, and may be used to advantage on finished work, more especially on cupboard-doors, refrigerators, etc.

Single-action spring-hinges are described in connection with screen-doors (Art. 410). (See, also, Art. 356.)

Fig. 583 shows the construction and application of the "Soss" invisible hinge.† This hinge is especially adapted for use where it is undesirable to have the hinges visible, as in panel-doors or secret doors. It is often used to hang ordinary doors and can be used for doors up to 2½ inches in thickness. Three hinges should be used for heavy doors. The hinge is made of a frictionless, composition-metal, is roller-bearing, and is applied to the same parts

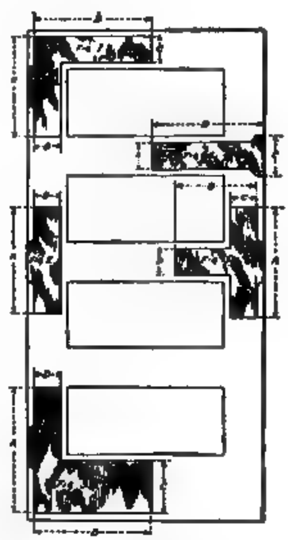


Fig. 584. Application of Various Types of Hinge-Plates and Straps to a Door.

* Manufactured by the Stanley Works, New Britain, Conn.

† Manufactured by the Soss Manufacturing Company, Brooklyn, N. Y.

of the door and frame as an ordinary butt. It is much used for furniture, pianos, and cabinet-work.

The outline of the door shown in Fig. 584 illustrates the application of various types of hinge-plates and straps, both right-hand and left-hand. Thus, Fig. 1, in the drawing, is a left-hand top plate or a right-hand bottom plate.

348. BUTTS. DESCRIPTION OF DIFFERENT KINDS. Common hinges are made in such a manner that the two leaves cannot be separated, the pin being riveted in place; so that the door or shutter cannot be taken off without unscrewing the hinge. This would be a very grave objection in the hinges of full-size doors for houses, etc. The desirability of being able to remove the door at times without unscrewing the hinge, as well as considerations of appearance and

Fig. 585. Stanley Ornamental Hinge.

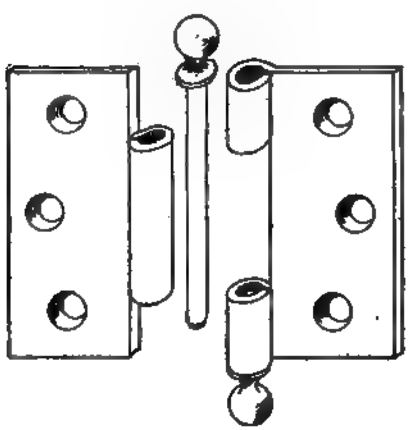


Fig. 586. Loose-Pin Butt.

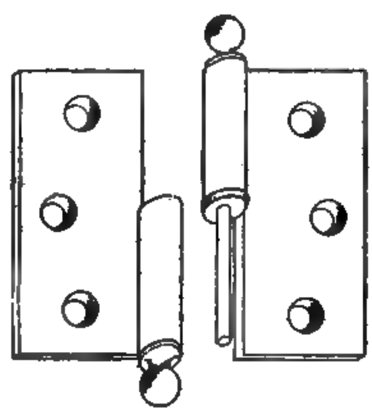


Fig. 587. Loose-Joint Butt.

safety, has led to the universal custom of hanging the doors in all finished buildings with hinges like those shown in Figs. 586 and 587 which permit the door to be taken off when open without the hinge being removed. These hinges are called "butts," as they are screwed to the butt-edge of the door and the face of the jamb. When the door is closed the leaves of the hinge, and consequently

the screws, are concealed, so that the hinge cannot be removed.

Butts such as are shown in Fig. 586 are called "loose-pin butts," and the butt shown in Fig. 587 is a "loose-joint butt." Loose-joint butts are finished with and without tips, but loose-pin butts always have them. When hung with the latter the door can be removed by withdrawing the pins and slipping the hinges apart. With the loose-joint butt all that is necessary is to swing the door so that it will clear the trim; it can then be lifted from the hinge.

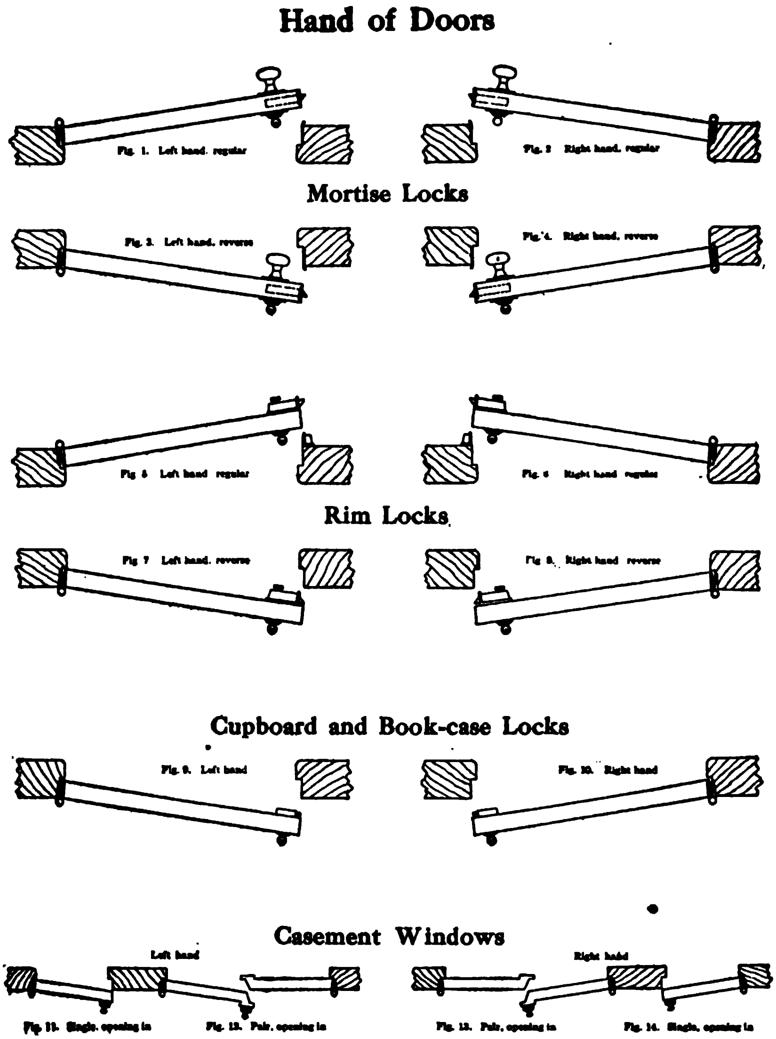
The use of these butts varies in different localities. In present-day practice on full-size doors the five-knuckle loose-pin butts are generally used, in preference to the old three-knuckle butts. The loose-pin or tight-joint butt is in almost universal use, 95 per cent of those now used being of this variety; the loose-joint butt is seldom if ever used.

Loose-pin butts possess two advantages: the first and most important one is that the bearing-surface is increased to a maximum, and as the pin is distinct from the leaves it can be made of a metal that will stand more wear than that used in the butts. The smallest butts generally have two bearings and three knuckles, and those 3½ inches high and over, four bearings and five knuckles. The loose-joint butt has only one bearing.

The second advantage possessed by the loose-pin butt, and probably the one which most influences its use, is that as either leaf can be fastened to the jamb, the butt can be used on either a right or a left-hand door. This often saves much inconvenience when the door is being hung.

With loose-joint butts the part containing the pin must be screwed to the jamb, and this necessitates making such butts in "rights" and "lefts." To tell whether a door is right or left-handed is often confusing, but if the following simple rule be remembered no difficulty will arise. Rule: if the door swings *from* you to the right, it is "right-handed"; if it swings *from* you to the left, it is "left-handed." The "hand" of a door is always determined from the *outside*. The outside is the street-side of an entrance-door, and the corridor-side of a room-door. The outside of a communicating door, from room to room, is the side from which, when the door is closed, the butts are not visible. The outside of a pair of twin-doors is the space between them. The outside of a closet-door is the room-side, thus reversing the rule which applies in other cases. The foregoing definitions apply to sliding doors as well as to hinged doors. If, when you stand outside a door, the butts are on the right, it is a "right-hand door"; if on the left, it is a "left-hand door." This rule does not apply to casement-sashes, where the point of view is assumed to be from

the inside, instead of the outside. Further, with regard to locks, if when you stand outside the door it opens from you, or inward,



Casement windows opening out follow the same rule.

Fig. 588. "Hand" of Doors and Windows.

it takes a lock with a regular bevel-bolt; if opening outward it takes a lock with reverse bevel-bolt. As cupboard and bookcase-doors always open out, it is unnecessary to specify for their locks reverse-

bevel bolts, as locks for such doors are regularly so made. The "hand" of a lock varies according to the type of door on which it is to be used. Fig. 588 * shows the types of doors of various "hands" in common use. A door is beveled when the plane of its edge does not make a right angle with that of its surface. The standard bevel is 1/8 of an inch in 2 1/4 inches.

For locks the above rule applies only to doors that open in; if the door opens outward, a right-hand "reverse-bevel" latch will be required for a right-hand door, and *vice versa.* Reverse-bevel latches, however, are usually required only for locks in which the key can be used from the outside only, as in front-door and vestibule locks, rim night-latches, etc.

There is another point about the loose-pin butt which is sometimes an advantage and sometimes the reverse, namely, that by slipping out the pins the door can generally be opened, even when locked. The doors should therefore be hung so that the pins will not be within the reach of burglars. With the loose-joint butt it is impossible to open the door, when locked, without breaking the lock or butts.

Where loose-joint butts are used great pains should be taken to hang the door so that both butts will bear evenly; in many instances it will be found that one butt alone carries the weight of the door.

Butts are now made with beveled knuckles for raising doors up and over thresholds.

Ornamental surface-butts save time and labor in hanging doors. Only the casement is mortised; the ornamental leaf is screwed to the surface of the door. These hinges are reversible and can be used on either right or left-hand doors. The hinge is quickly reversed by unscrewing the ball tip, which is slotted for the screwdriver, reversing the pin, and screwing the tip in the opposite end of the joint. These butts are made in sizes from 2 to 4 1/2 inches at the joint, and can be supplied in any desired finish to match the other hardware.

The proper hanging of the doors of a new building is a detail worthy of most careful study by the architect. Creaking, binding, poorly made hinges never cease to give trouble and annoyance to the owner. Ball-bearing hinges seem to meet the tests of efficiency required by carefully drawn specifications. They are made of high-quality wrought bronze or cold-rolled steel, carefully selected and tested. These hinges will not sag, creak nor bind. Careful and complete tests have been made as follows: a door weighing 150 pounds, hung on two 5 by 5-inch Stanley ball-bearing hinges,

* Furnished by the Yale & Towne Manufacturing Company, New York City.

was opened and closed one million times. It was found that the hinges had worn away to the extent of less than 1/32 of an inch, the exact figure being .019. This test conclusively proves the superior wearing-qualities of these hinges. Oiling is not necessary with this ball-bearing hinge,* as the bearings are completely protected from moisture and dust by a brass cap. This is an important point, as oiling injures the finished surface of the hinge and at the same time causes the accumulation of dust and dirt in the joint.

Another feature of this type of ball-bearing hinge * is the patented non-rising pin. The small wings on the pin fit into corresponding slots, and make it impossible for the pin to work up out of the joint. The pin is easily slipped in and out, but does not rise under the action of the door. The ordinary type of loose pin is very commonly found projecting from the joint, giving the hinge an unsightly appearance. These hinges or butts are finished in all of the popular styles and finishes. In one type of this butt † the washers are not visible.

In Fig. 591 ‡ is shown a wrought-steel butt with five knuckles, that is steel-bushed throughout the entire length of each knuckle. It is self-lubricating.

349. MATERIALS USED FOR BUTTS. Butts are made of cast iron, malleable iron, wrought steel, bronze and brass. For the very best work solid-bronze or brass butts or bronze-plated-steel butts should be used. Steel butts are very heavily plated and finished so that they cannot be detected, when on the door, from solid-bronze metal. The author believes that for the inside doors of dry buildings they are in all respects as desirable as solid-bronze or brass butts, if not more so, on account of greater strength. As butts are not subject to wear on their face, there is no danger that the plating will wear through. Steel butts will rust in time, and if they become tarnished cannot be polished.

Front doors, or doors hung in damp situations, should be hung with solid-bronze or brass butts, or iron butts Bower-Barffed or finished in "rustless iron." If these cannot be afforded, japanned butts answer very well.

The cheaper grades of butts are made of cast iron, either in the plain iron, japanned, lacquered or plated. A well made cast-iron butt with heavy knuckles will resist wear at the knuckles better than one of steel. For high-grade work, where an iron or steel

* Manufactured by The Stanley Works and P. & F. Corbin, New Britain, Conn., and various other firms.

† Manufactured by P. & F. Corbin, New Britain, Conn.

‡ Manufactured by the Russell & Erwin Manufacturing Company, New Britain, Conn. A similar butt is made by Sargent & Company, New Haven, Conn.

butt is to be used, the cast-iron butts are better but more costly than the steel. Heavy cast-iron butts that are finely finished are now made by nearly all manufacturers of good hardware. These butts will outwear any butt except one made of bronze with ball-bearings. If a cheap butt must be used the japanned butt will generally be found to wear the best.

350. WASHERS USED FOR BUTTS. It is now the custom of the large manufacturers to fit their bronze, brass or iron butts of the better grades with some form of self-lubricating ball-bearing or "fiber-washer," to reduce the wear on the bearing-surfaces. The more general custom, except in the use of the ball-bearing and some fiber-washers, is to countersink the washers in the hubbs of the butt, so that they will not show externally. With wrought-steel butts washers are quite necessary, especially for very heavy doors.

Fig. 589. Stanley Ball-Bearing Washer.

One firm has recently patented an improved ball-bearing washer for its butts, to be used for very heavy doors; this washer practically eliminates all friction and increases the wearing-quality. Two of these washers are used on the standard loose-pin butts (see Fig. 590 *), and four on the extra-heavy loose-pin butts. The bearings are turned from hardened tool-steel, and will each safely sustain a load of 1,000 pounds without crushing. The load of the door is carried on these bearings. An enlarged view of the washer is shown in Fig. 589.*

Fig. 590. Stanley Ball-Bearing Butt.

The best-quality bronze or brass butts are fitted with self-lubricating steel washers. These are perforated and filled with a non-fluid lubricant which prevents wear and creaking.

* Manufactured by the Stanley Works, New Britain, Conn.

One manufacturer * makes a fiber-washer with a shoulder, for use with its butts. This form of washer will not become detached from the butt when the pin is removed.

351. SIZES OF BUTTS. Butts are made in sizes varying by half-inches from 2 by 2 to 5½ by 5½ inches, and above that by inches to 8 by 10 inches. Larger sizes than 6 by 6 inches are seldom used, as it is much better to increase the number of butts rather than the size.

In specifying the sizes, 3½ by 3½-inch butts may be used for 1⅜-inch pine doors not over 2 feet 8 inches wide; 4 by 4-inch butts for doors 1¾ inches thick and 7 feet high, and 4½ or 5-inch butts for heavier doors. Doors over 7 feet 6 inches high should be hung with three butts, and it would be better to hang a 7-foot door with three 4 by 4-inch than with two 5 by 5-inch butts, as three butts will prevent the door from springing in the middle.

Fig. 591. Russell & Erwin Wrought-Steel Butt.

It sometimes happens that a 4 by 4-inch butt will not allow the door to swing back parallel with the wall without striking the trim of the door. For such cases butts wider than they are high are made, as 4 by 4½ inches and 4 by 5 inches. The butts should always project beyond the face of the door a sufficient distance to throw the door out beyond the trim, as shown in Fig. 592.

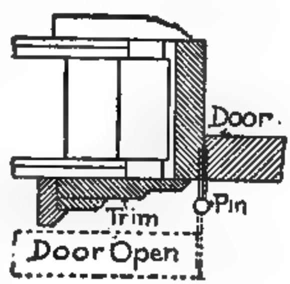


Fig. 592. Relation of Butt to Door.

The outside doors of public buildings should always open outward, should be so hung as to swing back out of the way, and should be provided with a door-holder or hook or other means of keeping them open when desired.

One type † of frictionless hinges is intended especially for very heavy doors. One top hinge and two or

* P. & F. Corbin, New Britain, Conn.

† Manufactured by Sargent & Company, New Haven, Conn.

more lower hinges are used. The top hinge is long, narrow and roller-bearing; it is placed upon the upper edge of the door and the under side of the door-frame. The lower hinges are ball-bearing and are placed upon the door in the usual positions.

352. DOUBLE-ACTION SPRING-HINGES OR BUTTS. If it is desired that a door shall swing in both directions, it should be hung with double-action spring-hinges. A door pivoted top and bottom near one edge would, of course, swing both ways; but as it is more or less trouble to control a double-acting door that does not have a spring-mechanism, so that it will stay at the proper place, a spring is a practical necessity on all "fly-doors," both to close them and to keep them in the proper position when not being operated. Double-action spring-hinges are especially desirable on pantry-doors opening into the dining-room, and on vestibule-doors in public buildings. They are sometimes used on outside doors of buildings of a semipublic character, but as a double-action door cannot be made tight, or cannot be well locked, it is better on such doors to use ordinary butts with some approved door-check.

There are many patterns of double-action spring-hinges on the market. Several of them are constructed on the same principle, but differ more or less in slight details and in the quality of the materials. The general principle of nearly all double-action spring-hinges or butts is that of two pins, one on each side of the door, joined by a central connecting plate which lies between the two leaves of the hinge or butt when the door is closed. This permits a door hung near one edge of the casing with a double-action spring-butt, to be swung through 180 degrees back to the wall and fastened in an open position out of the way. It is illustrated by the two diagrams in Fig. 593,* which show the position of the leaves of

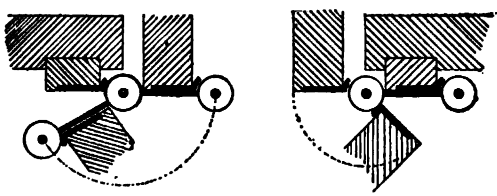


Fig. 593. Placing of Double-Action Spring-Hinges or Butts.

the hinge for different positions of the door. It will be noted that when the door shown at the right is opened toward the left, the central plate, with both barrels of the hinge, remains at the

* Illustration furnished by Bommer Brothers, Brooklyn, N. Y.

casing; and that when the door shown at the left is opened toward the right, the central plate, with one of the barrels, opens with the door. Where doors are hung in pairs this gives an unbalanced appearance when both doors are opened in the same direction or hooked back in open position. The "Bommer" or the "Triplex" double-action spring-hinge, may be applied to eliminate this objectionable feature.

The fact that with double-action spring-butt-hinges the weight of the door is alternately supported on the bottom bearing at one side of the connecting plate and on the top bearing at the other side of the connecting plate as the door moves from side to side, is utilized in the new "Bommer" hinge by placing the fixed spring-holders at these bearings and locating the movable spring-holders, which have the perforated collar for giving tension to the spring, opposite to the bearings. This arrangement of parts, in connection with the use of spiral springs, coiled in opposite directions or "pitch" to each other, at the opposite sides of the connecting-plate, and the introduction of easily replaceable washers at the joints moving in unison with the "ears" of the flanges, explains the principles on which this hinge is constructed. Heretofore, in the "Bommer" hinge, the weight of the door was supported on the "rim" of one of the barrels when moving in one direction, and upon an "ear" of the opposite flange when moving in the other direction. In the new "Bommer" hinge this construction is discarded; the weight of the door is equally distributed among the various parts, the friction upon the edge and inside of the barrels is relieved and the springs are thereby enabled to perform fully their proper function of keeping the door closed. The connecting-plate of this hinge is made of one piece of metal, and all is swedged together cold, without rivets. It is of even thickness throughout, has rounded edges and is of great strength. It is claimed by the manufacturers that time and trouble are saved for the carpenter by fitting pairs of double-action doors with these hinges because both doors can now be fitted from the same side of the opening; whereas formerly it was necessary to fit one door from one side and the other door from the other side of the opening. In order to put the weight of the door upon the correct bearings, the flange-spring which is screwed to the casing must have the perforated movable holder uppermost.

The principal difference in the other makes of hinges or butts lies in the arrangement of the spring or springs which close the door and bring it to its proper place after it has been opened. Most of the hinges have two springs, which may be either "simple" or "compound," one around each pin. These springs are clearly shown in the hinge in Fig. 594, which, however, in its detailed con-

struction, represents an old-style hinge, now obsolete. As the door is opened the spring about the pin on which the door swings is coiled tighter, and the reaction throws the door beyond the center,

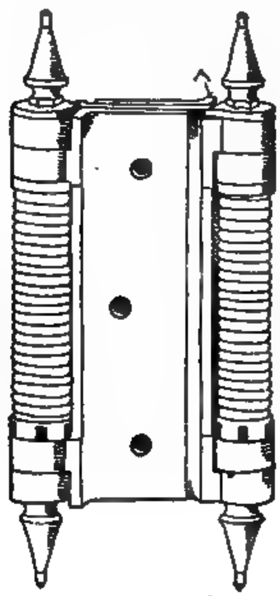


Fig. 594. Spring-Hinge.

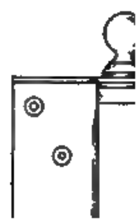


Fig. 595. Bommer Spring-Hinge.

bringing the stress on the other spring which reacts in the same way. All high-class hinges of this type now have the springs concealed within hollow cylinders.

Of hinges or butts of the type described above, the "Bommer,"* "Triplex,"† "American"‡ and "Oxford"‡ are among those extensively used on good work.

The new "Bommer" hinge is shown in Fig. 595.* One flange is screwed to the jamb, care being taken to have the perforated torsioning spring-holder uppermost, and the other flange is screwed to the edge of the door. A raised shoulder on the upper and lower edges of the flanges serves as a gauge to the carpenter in putting on the hinge and securing accuracy in fitting. Another peculiar feature of this hinge, in the large sizes, is the use of compound spiral springs inside of the cylinders; these springs give a very light and elastic movement, combined with great power. A partial section through one of the cylinders of the larger sizes, Fig. 596, gives an idea of the construction. These hinges are made of wrought steel, plated,

* Manufactured by Bommer Brothers, Brooklyn, N. Y.

† Manufactured by the Chicago Spring Butt Company, Chicago, Ill.

‡ Manufactured by the Columbian Hardware Company, New York City.

and in bronze-metal or brass, in sizes to fit any door. The bronze and brass-metal hinges have a continuous steel core or skeleton running from end to end. The wear comes entirely upon this steel interior, and not in the least upon the bronze or brass exterior; thus the disadvantages of bearings of soft bronze-metal or brass are overcome. Single-action hinges and special patterns for office-gates and water-closet doors are also made with the same kind of springs.

Fig. 596. Section Through Cylinders of Bommer Spring-Hinge.

The "American" spring-hinge is very much like the hinge shown in Fig. 594, except that the spring is encased in cylinders made with six knuckles, resembling the joint of a loose-pin butt. This is a very powerful hinge, suitable for very heavy doors.

The "Oxford" hinge somewhat resembles in its general appearance the "Bommer" hinge, but is cheaper and more suitable for light doors.

353. TYPES OF SPRING-HINGES. As has been indicated above, spring-hinges suitable for closing double-acting doors, after they have been opened, are of two general types. Those of one type are constructed with two axes, one on each side of the door. Those of the other type have only one axis and operate on pivots. Of the double-axis type of spring-hinges, the "Chicago" * and the "Triplex" * are extensively used. They are, however, distinctly different in construction, although both are applied to the jamb of the door. Of the single-axis type, three spring-hinges, the "Relax," * the "Premier" * and the "Chicago" * are in very general demand. These three hinges are of decidedly different construction. The "Relax" * and the "Premier" * are applied to the surface of the floor and the entire mechanism is in the door. The "Chicago" mortise floor-hinge * is fixed in a hole in the floor.

354. MATERIALS AND SIZES OF SPRING-HINGES. All of these are made in wrought steel, bronze or brass-metal and are finished in any plated finishes to match other hardware. All spring-hinges are made in various sizes to fit different thicknesses of doors. It is advisable, when specifying, to consider that a wide, low door is more difficult to swing than a narrow, high door of the same weight and thickness. For double-acting doors the largest hinge should be specified which the thickness of the door will permit.

355. TYPES OF DOUBLE-AXIS SPRING-HINGES. The

* Manufactured by the Chicago Spring Butt Company, Chicago, Ill.

"Chicago Triplex" *· spring-butt is shown in Fig. 599. This type of hinge is attractive in appearance and efficient in action. The action is produced by two coil-springs, each concealed in a cylinder, one on each side of the door. The spring has a torsion-action. The tension may be adjusted by means of the tension-lug in one end of each barrel. This lug engages with one end of the spring and is adjustably fastened to the flange with a rivet. One flange fastens to the jamb and the other to the door. The lugs in the ends of the barrels operate in hardened bushings, and wear and friction are thereby reduced to a minimum. The unique feature of this hinge is the formation of the body, which is constructed of two barrels and a connecting web. As the body is one integral piece, it can be made entirely of heavy metal, with three-ply ("Triplex") heavy metal at the end parts between the barrels. This integrity of construction makes the use of rivets for fastening separate parts together unnecessary. The bronze and brass-metal hinges have a specially constructed body with a seamless, intact metal-surface and interior steel construction, by which wear or breakage is eliminated. These hinges are made, also, for single-acting doors and also with a box flange for clamping to marble partitions in hanging water-closet doors.

The "Chicago" double-acting spring-butt is shown in Fig. 597.* This type of hinge is particularly adapted to light doors subject to excessive use. The action is produced by a single large coil-spring which is encased in a box frame and completely concealed when the door is closed. The spring has both a torsion and a leverage-action, and imparts an easy but positive movement to the door. Fig. 598 * shows the "Chicago" double-acting blank butt. Light, narrow doors are often equipped with one spring-butt and one blank butt. In such case the blank butt must always be placed at the bottom of the door as it has no spring-power to carry any weight and acts rather as a guide. Such a combination is economical and very satisfactory, as the spring-power is at the top of the door where it is actually required.

The "Chicago Triplex" lavatory-door spring-hinge is shown in Fig. 600. This hinge is suitable for clamping to marble partitions and can be furnished with a regular spring to close the door, or, when preferred, with a reverse-spring to throw the door open when released. This avoids the necessity of an indicator-bolt on water-closet doors, as they are held open when not bolted shut.

356. TYPES OF SINGLE-AXIS, PIVOT-HINGES AND FLOOR-HINGES. The "Chicago Relax" spring-hinge is shown

* Manufactured by the Chicago Spring Butt Company, Chicago, Ill.

in Fig. 601.* This type of hinge is particularly suitable for high-grade residence interior doors, such as those between dining-room and butler's pantry. The unique feature of this hinge is the mechanism by which stepping on a lever disengages the spring-action and allows the door to be placed open at any desired angle. The spring-action automatically re-engages as the door is closed. This hinge has a torsion-spring, the tension of which is easily adjusted. The weight of the door is carried on ball-bearings, located in the top of the hinge-frame. The hinge is of the single-axis type and is noiseless in operation. The application is very simple as it is applied to the surface of the floor and into a rectangular saw-cut in the door.

The "Chicago Premier" spring-hinge is shown in Fig. 602.* This type of hinge has a flat-wire compression-spring which is operated by a piston acting against an eccentric. It holds the door open when it is opened to 90 degrees in either direction and is known as a "hold-back hinge." The weight of the door is carried on ball-bearings and the eccentrics are equipped with roller-bearings, so that wear and friction are reduced to a minimum. The application is very simple as it is fastened to the surface of the floor and into a rectangular saw-cut in the door. An alignment-feature allows the carpenter to align the door with the casing after it is fitted.

The "Chicago" mortise floor-hinge is shown in Fig. 603.* This type of hinge is set in a hole in the floor and operates the door by a torsion-spring. The tension is adjustable and the weight of the door is carried on ball-bearings in the bottom of the hinge-box. The upper end of the hinge-pintle has a square end which engages with a shoe. This shoe is mortised into the door. A side plate on each side of the door fastens to this shoe with screws, and clamps the door rigidly to the shoe. The position of the mechanism of the hinge below the floor permits the use of a spring of large diameter. Cutting into the floor for it, however, frequently interferes with girders or iron beams. Where the floor is of tile or concrete, a box is furnished to imbed in it and in this box the hinge is fastened with machine-screws.

A serviceable hinge for double-acting doors, which has been on the market for some years, is the "New Idea" double-acting spring-hinge, shown in Figs. 604 † and 605.† The door swings on a pivot or pintle, which is supported by the arms *A*, Fig. 605, of the jamb-plate, and let into the door, so that nothing but the face-plates

* Manufactured by the Chicago Spring Butt Company, Chicago, Ill.

† Manufactured by the Stover Manufacturing Company, Freeport, Ill.

Fig. 597. Chicago Spring-Butt.

Fig. 598. Chicago Blank Butt.

Fig. 599. Chicago Triplex Spring Butt.

Fig. 600. Chicago Triplex Lavatory-Door Spring-Hinge.

Fig. 601. Chicago Relax Spring-Hinge.

Fig. 602. Chicago Premier Spring-Hinge.

Fig. 603. Chicago Mortise Floor-Hinge.

and the arms of the jamb-plate are exposed. With this hinge it is advisable to use a concave jamb-strip, as shown in Fig. 604. This, however, is not always necessary and is not always done; often a quarter-round is run on the casing on each side of the jamb-plates and this answers the purpose, but does not make quite so good a job. The concave jamb-strip is more ornamental than the plain strip commonly used, and the joint between the door and strip is much closer than is possible with some double-acting hinges; but as

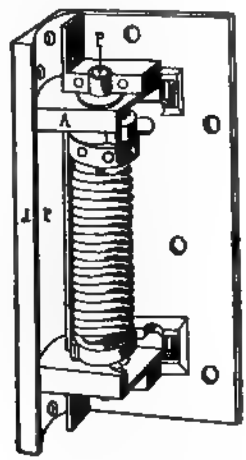


Fig. 604. New Idea Double-Acting Spring-Hinge.

Fig. 605. Detail of Construction of New Idea Double-Acting Spring Hinge.

the door cannot leave its pivot, it cannot be swung around through 180 degrees and fastened back to the wall out of the way of the opening. The leaves of the hinge that are fastened to the door divide on the line of the pintle for convenience in applying; this also allows of two finishes on one hinge. Besides the plain hinge shown in Fig. 604, ornamental hinges are made. Aside from the ornamentation these patterns differ from the plain ones in that the jamb-plate has molded edges which are exposed. The wooden jamb-strip is made of the same profile and cut against it. Bommer Brothers, also, make several forms of pivot-hinges of both vertical and horizontal types. Practically all the large hardware-manufacturers make floor spring-hinges which can be adjusted, as to tension, without removing the door. They are usually double-acting to swing both ways, and are made of iron, wrought steel, wrought bronze and wrought brass in various finishes.

The floor-hinge is in many cases succeeding the double-acting spring-butt, at least for residence-work. It is made as a simple hinge or as a checking-hinge, the checking-mechanism being encased and set below the floor. The "Russwin" * floor-hinges are so constructed that the tension on the spring can be changed at any time without taking down the door. By removing half of the divided cover-plate easy access can be had to all working-parts. The majority of the large manufacturers also make hinges of this or a somewhat similar type. Pivot-hinges for use on secret doors are made by at least one manufacturer.†

357. CHECKING SPRING-HINGES. For many years a checking spring-hinge has been extensively used for both double and single-acting doors in first-class buildings. With this hinge the door is hung on two pivots, one fitting into the adjustable socket mortised into the top of the door, and the other working in connection with a spring and checking-mechanism contained in a hermetically sealed casing sunk in the door-sill. By means of the checking-liquid the swing of the door is positively controlled, and the door closed without slamming. The spring-mechanism is so designed that the spring-tension does not increase as the door is opened. The maximum power is exerted by the spring when the door is in its closed position. This type of hinge is used when it is desirable to eliminate all projections from a door, and, in some cases, the body of the hinge is set below the door-sill, with the

Fig. 606. The Bardsley Single-Acting Checking Spring-Hinge.

Fig. 607. Detail of Top Pivot of Bardsley Single-Acting Checking Spring-Hinge.

bottom pivot projecting through the sill into the door itself; thus the hinge is entirely invisible. Figs. 606 ‡ and 607 ‡ show details

* Manufactured by the Russell & Erwin Manufacturing Company, New Britain, Conn.
† P. & F. Corbin, New Britain, Conn.
‡ Manufactured by the Joseph Bardsley Manufacturing Company, New York City.

of this checking spring-hinge for use on single-acting doors. Several other manufacturers make similar devices and each maker claims some points of superiority over the others. The "Russwin" pivot-hinges, shown in Fig. 608,* are made of extra-heavy cast bronze, and, as they are ball-bearing, they will carry the heaviest of doors.

Fig. 608. The Russwin Pivot-Hinge.

358. SPRING-HINGES WITH REVERSE-SPRINGS. A special single-action spring-butt-hinge (Fig. 609 †), with reverse-springs to throw the door open, is much used to hang the outside doors and stall-doors of fire-engine houses. For extra-heavy, large, or wide, front doors, three or four of these hinges should be used. They are made of solid brass or bronze, or of japanned or bronze-plated malleable iron, with springs protected from the weather. Fig. 610 ‡ illustrates the surface-type of the "Chicago" fire-engine house and garage spring-hinge, and Fig. 611 ‡ the mortise-type of the same hinge. Fig. 609 is used in connection with automatic latches similar to Fig. 612.† The latch is usually fastened above the door, and is released by pulling a wire carried to a convenient point in the engine-house, usually over the driver's seat of the foremost piece of apparatus. When the latch is released the door swings open automatically. When closing, the door depresses the latch and strikes against the spring-bumper, which checks its momentum; the latch then springs back into place and holds the door against rebound. Fig. 612*a* ‡ illustrates the "Chicago" checking-bumper and holder mortised into the floor and used with Figs. 610 and 611. Fig. 612*b* ‡ illustrates a type of door-bolt much used on fire-engine house and garage-doors.

* Manufactured by the Russell & Erwin Manufacturing Company, New Britain, Conn.
† Manufactured by Bommer Brothers, Brooklyn, N. Y.
‡ Manufactured by the Chicago Spring Butt Company, Chicago, Ill.

359. SLIDING-DOOR HANGERS.* Sliding doors are now almost always hung from the top by hangers which roll on a track secured to the inside of the studding or hung from the header above the opening and pocket. There are a great many styles of hangers and several kinds of tracks in the market, and it is often puzzling to the architect to know what to specify. With any hanger that rolls on a track the most important considerations, aside from strength, are the friction of the hanger on the axle, and, if on a fixed track, a practical arrangement for adjusting without taking off the door; the matter of noise is also an important consideration with house-door hangers. The track, also, is nearly, if not fully, of equal importance with the hanger; it should be straight and capable of adjustment in case the studding to which it is attached should settle. In most of the hangers the friction is reduced by permitting the hanger to roll on the axle while the wheels of the hanger are rolling on the track, although several of the latest devices have ball or roller-bearings.

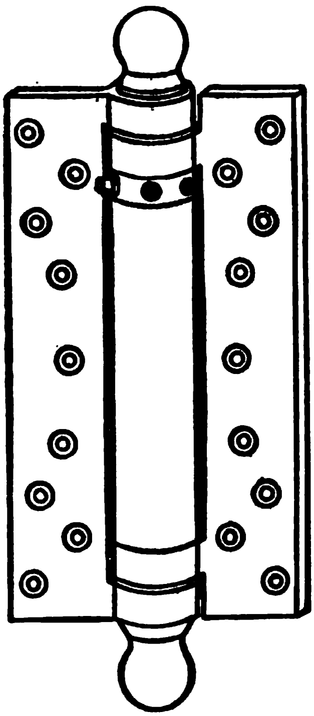


Fig. 609. Bommer Special Single-Action Spring-Butt.

One of the best combinations of track-hangers that the author has yet seen is that of the "Richards No. 221, Advance" noiseless ball-bearing trolley house-door hanger, with adjustable track, shown in Fig. 613. As will be seen the track is of the wood-lined clincher type with hard-maple runway. The track is secured to a wood header above by adjustable screws and can easily be removed after the walls are plastered. The wheels of the hanger have a raised rim which fits into the groove in the track, so that they cannot possibly get off the track and, at the same time, each wheel has a bearing on each side. The wood-lined track practically does away with all noise, and the door, being suspended from a point midway between the trolley-wheels, hangs perfectly. The hangers have forged-steel yokes and the axles of the wheels have ball-bearings, which reduce the friction to a minimum. The doors can

* Much of the matter on door-hangers was furnished by the Richards-Wilcox Manufacturing Co., Aurora, Ill.

also be slightly raised or lowered by an adjusting-screw on the bottom of the hanger. The wooden header shown in Fig. 613 is furnished with the track, so that the putting up of the track is a very simple matter. This hanger and track requires a clear space of 2¼ inches between the studs, and a vertical height of 6½ inches from the top of the door to the top of the track-header shown in Fig. 613. (See, also, Art. 260, division 5.)

Fig. 610. Surface-Type of Chicago Fire-Engine House and Garage Spring-Hinge.

360. TROLLEY-TRACKS FOR SLIDING DOORS. Another very satisfactory arrangement for hanging sliding doors is a trolley-track similar to that shown in Fig. 614. The trolleys or wheels which carry the door run inside of the track as shown in Fig. 615. As the track is made of rolled steel, it possesses a great deal of strength, and therefore it requires but few supports and can readily be adjusted. It is absolutely impossible for the wheels to get out of place on this track, or for any dirt to get inside of it. It also requires less space between the studs than other tracks, 3 inches being sufficient for doors 1¾ inches thick. Several grades and kinds of hangers are made to suit different requirements.

The trolley-track is especially well adapted for large doors or sliding partitions which have to slide some distance. In such cases it will be best to place the doors outside of the partition and incase the track in a false beam or cornice, so that it can easily be gotten at for adjustment.

Trolley-tracks and hangers * for a variety of purposes are made by several manufacturers. The principle of construction is practically the same in each, but the details are different. The "Lane" hanger of this type is arranged on the side-adjustment principle, which prevents the rubbing of the door and permits adjustment if shrinkage or swelling occurs. (See, also, Art. 260, division 5.)

361. SINGLE IRON-BAR TRACKS FOR SLIDING DOORS. Next to the trolley-track the author would place the single iron-bar track, one type of which, the "Lane," is shown in

* Manufactured by the Richards-Wilcox Manufacturing Company, Aurora, Ill., Lane Brothers Company, Poughkeepsie, N. Y., the Coburn Trolley-Track Manufacturing Company, Holyoke, Mass., and other companies.

Fig. 616. The track is placed directly over the central vertical longitudinal plane of the door and is attached to a board called the "track-plate" by means of iron brackets riveted to the track and screwed to the track-plate. This track-plate should be one piece of well-seasoned pine of the same length as the track; it should be put up perfectly level and securely nailed to the studding. A plank, *H*, Fig. 616, should be securely nailed between the two lines of studs, a sufficient distance above the track to keep the space of uniform width, prevent the studs from springing and protect the wheels and doors from dropping plaster. The track, being of steel, cannot warp, and as it is attached to but one side of the partition, it is not subject to derangement in case the two sides should settle unequally.

The single track is now used by several manufacturers, that and the trolley-track having almost displaced the double wooden track, except for cheaply constructed buildings.

Fig. 611. Mortise-Type of Chicago Fire-Engine House and Garage, Spring-Hinge.

The hangers used on these tracks require an accessible and practicable means of adjustment, so that either the front or back edge of the door may be raised in case the bearing-partition settles; and an anti-friction provision should be installed

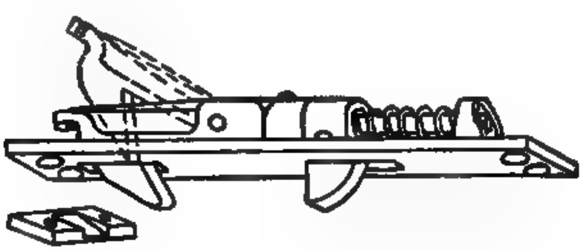


Fig. 612. Door-Holding Mechanism Used with Bommer Special Single-Action Spring-Butt.

for the wheels. The method of adjustment varies with each make of hanger, but a great many have an adjustment somewhat similar to that shown in Fig. 618, which works very well for the front edge of

the door, but cannot so readily be got at on the back edge. This adjustment also necessitates right and left-hand hangers. Several hangers are adjusted by means of a serrated screw, as in Fig. 617, which represents the "Lundy" * hanger, and in Fig. 620, the Lane "New Model" parlor-door hanger.

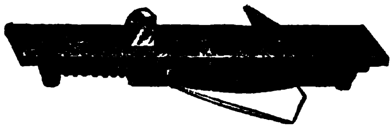


Fig. 612a. Chicago Checking Bumper and Holder.

Previous to the introduction of the roller and ball-bearing hangers the provision for anti-friction had generally consisted in permitting the axle of the wheels to roll in a slot in the hanger-carriage, as shown in Fig. 617, and this has been found to give very satisfactory results for parlor-doors. If a door has to slide a long distance, however, this arrangement becomes impracticable on account of the great length of slot required. For ordinary parlor or barn-doors, a sufficient length of slot can easily be provided, and hangers of this style are much to be preferred to cheap roller or ball-bearing hangers. In fact, it is generally admitted that there is no bearing so poor and unreliable as a poor quality ball-bearing. A ball-bearing hanger, therefore, that is sold for less than the standard hangers, should be looked upon with suspicion. Roller-bearings are more durable, as the rollers, when of the same quality, have a greater crushing-resistance.

Fig. 618 shows the "Lane" † single-rail, ball-bearing parlor-door hanger, which is the same as this company's standard hanger except in the bearing, the "Standard" hanger having a slot-bearing similar to that in the "Lundy" hanger. The ball-bearings in the "Lane" hanger have cups and cones carefully made and hardened, and polished-steel balls guaranteed not to crush, the quality and workmanship being equal to that in high-grade bicycle-bearings. This bearing adds slightly to the cost of the hanger, as well as to its working-quality and durability. Ball-bearing and roller-bearing hangers are, of course, adapted to any length of track. Fig. 619 shows the details of application of the "Lane" trolley door-hangers to parlor-doors.

The "New Model," † parlor-door hanger, shown in Fig. 620, represents, perhaps, one of the best of the low-priced hangers, the reduction in cost being due to the smaller amount of material and somewhat less labor required in its construction. It has roller-bearings running on a hard-steel bushing. The adjustment is made

* Manufactured by the Richards-Wilcox Manufacturing Company, Aurora, Ill.

† Manufactured by the Lane Brothers Company, Poughkeepsie, N. Y.

by means of a nut with serrated projections or flanges both above and below the fastening-plate, so that the nut may be turned either from the edge of the door above the plate or from the side by removing the stop. (See, also, Art. 260, division 5.)

362. ADVANTAGES AND DISADVANTAGES OF DOUBLE-TRACK HANGERS. When parlor-door hangers were first introduced, two tracks, generally of wood, were used for the hangers to run on, and several types of double-track hangers are still used. As has been stated, the principal objection to a double-track hanger is that the two sides of a sliding-door partition are very apt to settle unequally, and leave the tracks at unequal heights, and this interferes with the proper working of the hanger. As long as the tracks are on a level, however, double-track hangers work fully as well as single-track hangers, and if there were no chance of the partition settling the double-track hangers would be preferable. (See, also, Art. 260, division 5.)

363. ELEVATOR-DOOR HANGERS. A perfectly noiseless, easy-running elevator-door hanger for apartment-houses, hotels, office-buildings, etc., is the "Invincible" * ball-bearing hanger. (See Fig. 622.) This hanger has perfect adjustment, a forged-steel yoke, and highest-grade hardened bearings; it has been used extensively in large cities throughout the country. Fig. 621 * illustrates one of the better types of double-track hangers.

Fig. 612b. Chicago Fire-Engine House and Garage Door-Bolt.

364. BARN-DOOR HANGERS. Barn-doors are now generally hung from an overhead track in much the same way as house-doors, except that the hanger, being exposed, is commonly screwed to the inside of the door.

* Manufactured by the Richards-Wilcox Manufacturing Company, Aurora, Ill.

Most of the manufacturers of parlor-door hangers also make barn-door hangers that work in about the same way as their house-door hangers. One type of trolley barn-door hanger * has the same form of track as that shown in Fig. 614, which varies in size to correspond with the size and weight of the door, and the hangers themselves are of the same general pattern, although the manner of attaching them to the door is entirely different. A vertical and lateral adjustment is provided to move the door sidewise in case it should warp or bind against the wall, or in case of any settling of the timbers. The trolley-track is especially suitable for places where the track is exposed, as nothing can possibly get into it and it requires no hood.

Fig. 613. Advance Ball-Bearing Trolley House-Door Hanger.

The Lane Brothers Company barn-door hangers and track are also quite similar to their standard parlor-door hangers and work very satisfactorily.

Fig. 614. Section of Trolley-Track.

Barn-doors so equipped should be provided with one or more stay-rollers at the bottom to prevent their being blown in and to keep them in line. (See, also, Art. 260, division 5.)

365. TRACKLESS DOOR-HANGERS. Besides the class of sliding-door hangers that roll on a track, there was also a distinct type of hanger which operated the door by means of a hinged or pivoted frame working on the principle of scissors or of a parallelogram, the corners of which are required to be at the same level. This frame was attached to the back edge of the door and the door was so made as to slide by it. These hangers are very little used to-day. (See, also, Art. 260, division 5.)

366. FOLDING-SLIDING OR ACCORDION DOORS. This method of hanging doors is used largely in churches, libraries, class-rooms, auditoriums and similar buildings. It economizes space and light and reduces the cost of construction. The parti-

* Manufactured by the Richards-Wilcox Manufacturing Company, Aurora, Ill.

tions can be put in to divide and subdivide spacious rooms for class-rooms, studios, etc., and then, when desired, can be folded up against the wall so that the entire room can be utilized as one. They are also used for piazzas in the winter. For these purposes

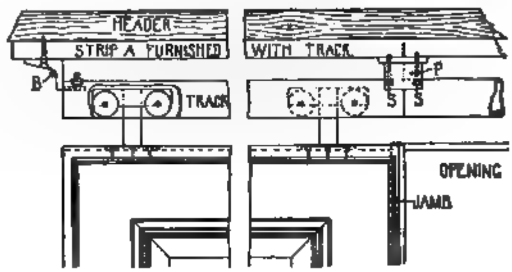


Fig. 615. Detail Showing Hanging of Door on Trolley-Track.

trolley-track, brackets and swivel-hangers are used; the hangers have vertical adjustment. (See Fig. 624.*) .These swivel folding-door hangers have been used very largely in the Young Men's Christian Assocation buildings throughout the country.

The doors should not exceed three feet in width. Any number of doors may be placed in the opening commencing with a half-door hinged to the jamb at either side of the opening. This half-door must be exactly one-half the width of the other doors, less the "throw" of the hinge as shown in Fig 623 * There should be one swivel-hanger on each alternate door only, and this hanger should be placed on the exact center of the top surface of the upper rail of the door (see Fig. 625 *). To accomplish this, it is best to hinge the doors together, fold them and strike a line across the centers and set hangers on this line; then when the doors are hung and folded back the hangers will be in perfect alignment and work easily.

Fig. 616. Detail of Application of Lane Hanger.

While by this means doors of much greater weight than one hundred pounds have been successfully hung, they should not, if possible, exceed this weight, as a hanger is used on each alternate door only; and when the doors are folded, the entire weight is con-

* Manufactured by the Richards-Wilcox Manufacturing Company, Aurora, Ill.

centrated on a few inches of track. The distance usually allowed from top of door to heading-timber is 5 inches (see Fig. 625). The track should be as long as the opening is wide, the brackets being spaced from 2 to 2½ feet apart. One manufacturer * makes a special swivel ball-bearing hanger for this purpose which works very satisfactorily. Fig. 626 * shows a perspective of a set of folding-sliding doors and a detail of the hanger used with them.

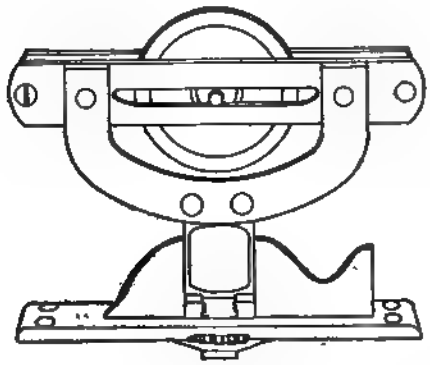


Fig. 617. The Lundy Hanger.

367. SLIDING-DOOR HANGERS FOR SCHOOL-ROOM DOORS. For dividing class-rooms in the public schools of our large cities, notably New York and Philadelphia, the boards of education have adopted extensively the use of sliding doors which are faced with slate blackboards and operate on parallel and curved overhead trolley-tracks and knuckle-joint ball-bearing hangers (see Fig. 627 *). These doors when in use form a perfectly straight line across the opening, and when so desired can be lined up side by side in a pocket occupying the space-width of one door. The doors used weigh from 500 to 800 pounds but they slide so easily and perfectly that a child can operate them. The "Richards-Wilcox, No. S-444" * flush door-hangers are supplied largely for this work.

When doors are hung as in Fig. 623 it is necessary to use, instead of butts, hinges similar to the one shown in Fig. 585. They are screwed to the face of the door, and at least three are used to a fold This company also makes several types of garage-door hangers for use under varying conditions. (See, also, Art. 260, division 5.)

Fig. 618. The Lane Ball-Bearing Hanger.

368. BALANCED DOORS. The outside doors of freight-elevator shafts and also of freight-sheds are usually hung to slide

* Manufactured by the Richards-Wilcox Manufacturing Company, Aurora, Ill.

up and down, as, generally, there is not room for swinging doors. When the expense will permit, self-coiling steel shutters or doors are considered the best means of closing such openings, but for

Fig. 619. Application of Lane Trolley Hangers.

ordinary mercantile buildings large single doors balanced by weights are more commonly used.

Balanced doors should preferably be hung from overhead pul-

Fig. 620. Lane New Model Parlor-Door Hangers.

leys, as in Fig. 628, with either metal bands or sash-chains for connecting the weights with the door. An 8-inch roller-bearing overhead pulley * is made, by means of which, with the use of cable-chain, wire cable or sash-ribbon, doors weighing up to 500 pounds may be raised or lowered with ease.

* Manufactured by the Gardner Sash Pulley Company, Morris, Ill.

369. LOCKS AND LATCHES. So many types of locks for securing the doors of buildings are now manufactured and on sale by hardware-dealers, that it is impossible to describe all of the different patterns. An attempt will be made to describe only the principal features common to most locks, the manner in which they work, and some of the special types of locks with which the architect should be familiar. Locks for metal doors and windows are made by several hardware-firms who furnish the manufacturers of metal trim with templates by which the proper mortises, screw-holes, etc., are made in the doors or windows. A "turret *-lock" is especially designed by one manufacturer for use on metallic fire-proof doors, whether hollow or with core.

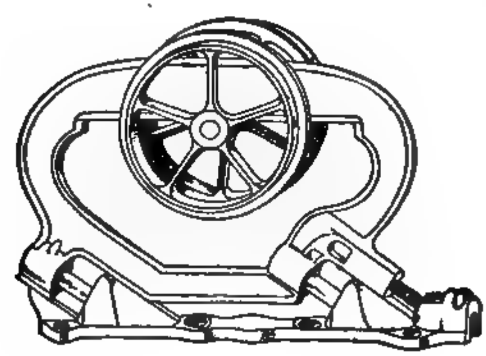


Fig. 621. Pioneer Wood-Track House-Door Hanger.

370. CLASSIFICATION OF LOCKS AND NAMES OF PARTS. In regard to their construction, locks may be classified as "lever tumbler-locks," "pin tumbler-locks," "cylinder-locks," "rim-locks," "mortise-locks" and "half-mortise locks." Rim-locks and mortise-locks, however, differ only in the shape of the case: a rim-lock is made to be fastened to the face of the door; a mortise-lock to be set into a mortise cut in the stile of the door. The internal construction is the same in both locks. Fig. 629 † shows lock-details of mortise lever-tumbler and mortise cylinder or pin-tumbler locks. The drawings show the "Yale" mortise cylinder, front-door lock; lock-cylinder and key; mortise lever knob-lock; and Triplex, knob-spindle, knob and escutcheon-plate. The following key explains the various parts of the locks:

Fig. 622. Invincible Ball-Bearing Elevator-Door Hanger.

* Manufactured by the Yale & Towne Manufacturing Company, New York City.

† Reproduced, by permission and redrawn from their catalogue, by the Yale & Towne Manufacturing Company, New York City.

Lock-Details and Names.

A. "Yale" mortise cylinder, front-door lock.
B. "Yale-lock" cylinder and its key.
C. "Yale" mortise lever knob-lock. ("Standard" type.)
D. "Yale Triplex," knob-spindle, knob and escutcheon-plate.

The names and functions of the several parts indicated by designating numbers are as follows:

1. Armor-plate of lock-front.
2. Front, or face, of lock.
3. Dead-bolt.
4. Stop-work.
5. Latch-bolt (antifriction type).
6. Cap.
7. Cylinder-ring.
8. Cylinder-head.
9. Plug.
10. Key-way.
11. Lock-case.
12. Cam (to operate bolt).
13. Cylinder.
14. Lock-front, or face.
15. Latch-bolt.
16. Thumb-bolt.
17. Hub (for spindle).
18. Heel of tail-piece.
19. Lever-tumblers.
20. Fence (on dead-bolt).
21. Gatings (of tumblers).
22. Spacing (of knob and key-hole centers).
23. Back-set (from front to knob center).
24. Latch-bolt spring.
25. Knob.
26. Knob-spindle ("Triplex" type).
27. Knob-screw (side or set-screw).
28. Knob-shank.
29. Thimble (on escutcheon-plate).
30. Escutcheon-plate.
31. Key (Yale-cylinder type).
32. Tail-piece.
33. Key-hole.

Fig. 623. Plan of Folding-Sliding or Accordion Doors.

371. LEVER-TUMBLER LOCKS. GENERAL DESCRIPTION. Lever-tumbler locks, sometimes called "bit-key locks" or bitted-key locks," are a common kind of locks operated by an ordinary key, and so called because the security of the lock depends upon "tumblers" or levers," which must be raised to an exact position before the bolt can be thrown. These locks differ a great deal in some of the details of their construction and also in the methods employed in their

Fig. 624. Detail Showing Adjustment-Equipment of Hanger.

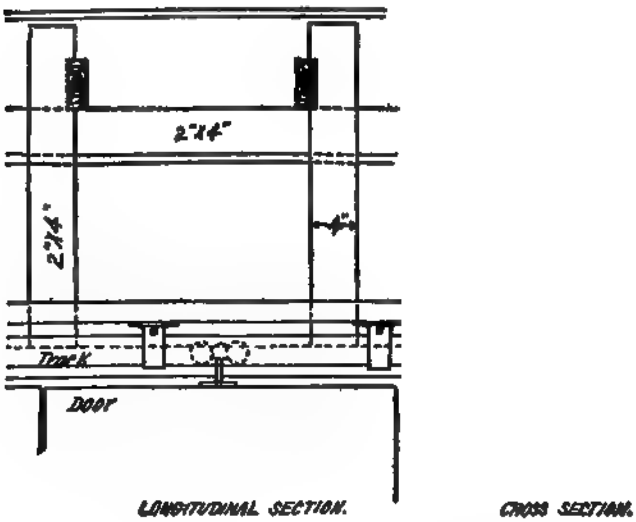


Fig. 625. Details Showing Installation of Folding-Sliding Doors.

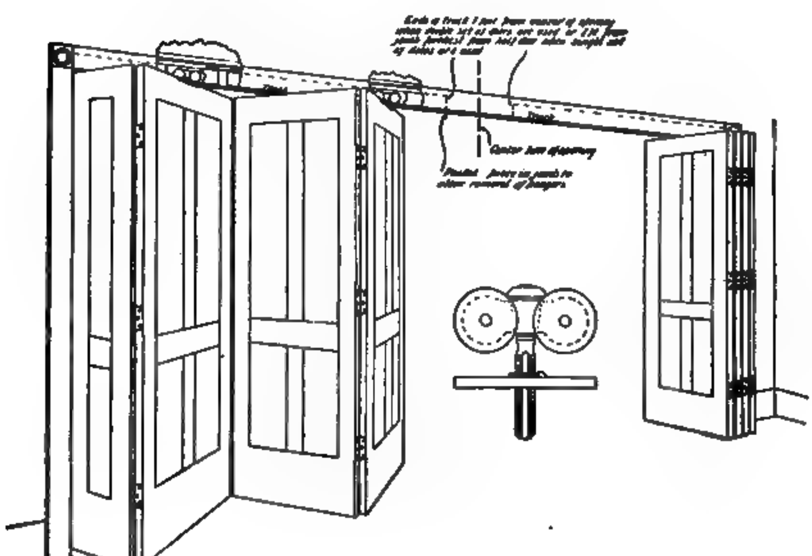


Fig. 626. Folding-Sliding Doors Using Auditorium Hangers.

manufacture. Most of the locks in common use have cast-iron cases and cast bolts, with only the springs and tumblers of wrought metal and in some of the cheaper locks even the tumblers are of cast iron. These locks were never a success and are now little used. In the very latest patterns of tumbler-locks, all of the parts, including the case, are made of wrought metal by means of the drop-forge which cuts and stamps the parts to the desired shape.

The ordinary tumbler-lock consists essentially of the following

Fig. 627. Detail of School-House Hanger Installation.

parts: (1) the "case," which contains the works, and to which the "wards" and "guides" are attached; (2) the "bolt"; (3) the "levers" or "tumblers"; (4) the "catch" or "latch" with its accompanying springs; (5) the "hub"; and (6) the "key." The hub and catch are not a part of the locking-apparatus, many locks having no latch, but they form a very important part of the ordinary house-door lock. The knobs and spindle might also be given as a part of the ordinary lock and latch, as they are necessary to operate the latch.

To enable one to understand the general principles upon which a tumbler-lock is constructed, and also the features that affect the quality of a lock, a short description of the various parts and the way in which they operate is given.

372. THE CASE. This part is usually made of cast iron, fin-

ished, usually in japan. Steel is sometimes used but steel-cased locks in the United States have not proved very successful and few of the higher grades are made of steel.

The cast case is made in the form of a shallow box, as in Fig. 630, with a flat cover, fastened in place by a screw. The front of the box in mortise-locks is usually of a separate piece of brass or bronze-metal, secured to the case by lugs and rivets. In the very cheapest locks the face is made of iron or steel.

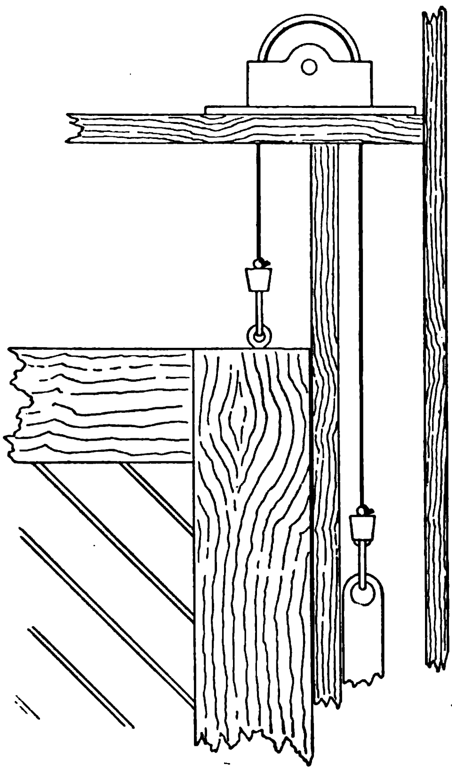


Fig. 628. Detail of Door Sliding Up and Down.

Most cases have a post, *B*, Fig. 360, cast with the box-part, and also guides for the latch-bolt.

373. THE WARDS. On the inside of the cover of the case near the key-hole a small projection, *W*, Fig. 630, is commonly cast, necessitating a corresponding cut in the sides of the key to allow it to turn. This projection is called a "ward." In ancient locks the wards were quite elaborate, and much dependence was placed upon them for the security of the lock. While it is true that wards prevent the use of any ordinary key not made to fit the lock, they do not interfere with the picking of the lock by an experienced lock-picker, and in the better grades of locks they are now usually omitted.

Another device often seen on cheap locks, to prevent the use of any but the right key in the lock, is a projection on the side of the key-hole, as shown in Figs. 630 and 632. The projection requires a corresponding depression in the face of the key, but as ordinarily made this is no safeguard against burglars, as a thin key can be slipped by the projection, or the projection, being of cast iron, can easily be broken off. A professional lock-picker, however, gen-

Fig. 629. General Lock-Construction.

erally uses pieces of stout wire to operate the lock, and against these, wards and key-hole projections are no protection.

374. THE BOLT. The bolt which secures the door is generally made quite heavy where it projects beyond the face-plate, but is thinned down inside the lock so as to be as light as possible and to give space for the levers. The general shape of the common cast bolt is shown in Fig. 631. The notch *A* is the point where the key catches, the post *B* is the part which catches in the levers, and the slots *C* fit over a guide-post on the case.

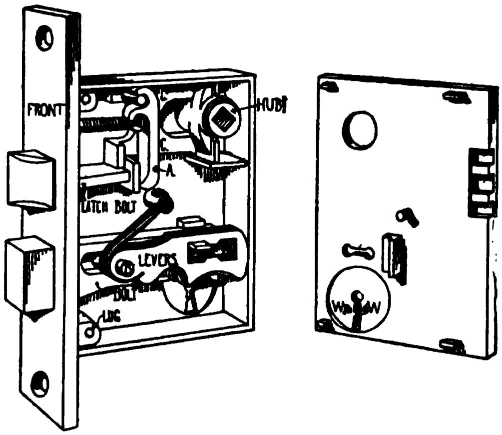


Fig. 630. Sargent's Easy-Spring Lock and Cover.

In all the best grades of cast locks the bolts are of brass or bronze, as an iron bolt is too easily broken.

375. THE LEVERS OR TUMBLERS. Levers or tumblers, the terms being used synonymously, are flat pieces of iron, steel or brass, usually fitted with a spring, which are so arranged in the lock that the bolt cannot be "shot" without lifting them. This can only be done by a key of the proper size and shape.

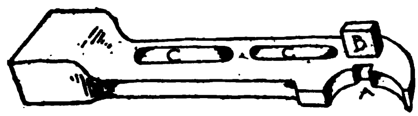


Fig. 631. Cast Dead Bolt.

There are from one to five levers in an ordinary lock and usually they are placed one over the other and pivoted over the guide-post, as shown in Fig. 630. The connecting gatings are cut at different heights so that the levers must be lifted unequally in order to permit the bolt to move. When the key is turned in the lock the cuts in the bit of the key, which are made to match the levers, bear against the "bellies," and lift the levers simultaneously until the gatings are exactly on a line with each other. The key then catches in the notch in the bottom of the bolt, the bolt-post passes through the gatings, and the levers drop as the key turns, catching behind the bolt-post and effectually preventing the bolt from being forced back.

There are many different arrangements of the levers and some-

times more than one set is used, but the general principle is the same in all lever-locks. It is obvious from the above description that the more levers a lock has the greater will be the security afforded, and, in fact, the only real security afforded by the common tumbler-lock is in the levers. A one-lever lock offers little security; a three-lever lock offers ten times as much. By transposing the levers and changing the height of the gatings a great many changes can be made, no two of which can be operated by the same key.

376. THE LATCH OR CATCH. This is in reality a spring-bolt with a beveled face intended to keep the door closed when shut into the jamb; it is operated by the knobs. There are three distinct kinds of latches in common use, the simple spring-latch, the antifriction latch and the stop-latch or front-door latch.

Nearly all of the later patterns of locks have an "easy-spring" action for the latch-bolt, which, although varying somewhat in different makes, usually consists of an arrangement of two springs, one only of which is brought into action when the door closes, while both resist the turning of the knob. This permits the latch-bolt to be easily pushed back, and at the same time holds the knob firmly.

This is more clearly shown in Fig. 632. This is the best type of construction and generally is the one adopted by all standard manufacturers for the highest quality of locks. When the latch-bolt is thrown back by striking the plate on the door-jamb it is resisted only by the light spiral spring around the shank of the bolt, but when the hub is turned it moves forward the carriage *C*, and also the plate *D* on the end of the latch, thus bringing into play the stronger spring in the carriage as well as the lighter one on the bolt.

Fig. 632. Lock and Latch.

In the "Sargent" type of easy-spring lock (Fig. 630), but one spring is used, the "easy" action being obtained by means of the

long lever *A*. This offers but slight resistance to the latch-bolt, while the turning of the hub, which draws back the carriage *C*, is directly resisted by the strong spiral spring. This is a good inexpensive lock.

Most lever-locks are now made with reversible latches. The latch-shank is of such shape that it may be turned over, after removing the cap, and used for either a right or left-hand door.

377. THE ANTIFRICTION STRIKE. This is more properly called the "antifriction latch-bolt." The ordinary form of latch is made with a V-shaped bevel, the long side of which strikes against a plate on the door-jamb. If the spring on the latch is at all stiff considerable force is required to push the latch back, and there is much wear on the bevel of the latch. To overcome this the antifriction latch-bolt was invented. Fig. 633 shows a form of antifriction latch-bolt used by several manufacturers. The strike is about 5/16 of an inch thick and is placed at the bottom or, in some makes, in the middle of the latch; the latter is considered the best construction. The strike is pivoted as shown and a peg on the strike works in a slot in the latch, which carries it back without friction on the sides. The antifriction strike is not required where there is an easy-spring action, although it is a desirable feature on front-door locks and on locks used for heavy doors.

Fig. 633. Anti-Friction Latch-Bolt.

A hinged latch-bolt is used by the various manufacturers in several types of locks. The bolt swings back into the face of the lock by means of a pivot or pin instead of sliding back as in the usual form of lock. It is operated by the knob from both sides and by the key from the outside. The outer knob, however, may be set by a stop, and the latch-bolt may be dead-locked from the inside by a thumb-turn, giving the security of a dead-lock.

378. THE HUB. This is a solid piece of metal, brass in the better grade of locks, which receives the spindle and turns with it. Two arms or cams are usually cast on the hub and these draw back the carriage as the knob is turned. The hub of the "Yale" locks is made of one piece of malleable iron or cast bronze, fitting accurately the flanged bearings of the case. This hub has an oblong opening for the spindle, with the larger dimension horizontal, to allow for that shrinking or swelling of the door which often causes the knobs and spindles of ordinary locks to bind. One firm of

* The Yale & Towne Manufacturing Company, New York City.

hardware manufacturers * makes a "gun-spring" hub which gives the hub or lever-handle action in one direction only. This hub is similar to that found in use on the continent in Europe.

379. THE KEY. The general shape of the key for ordinary tumbler-locks is shown in Fig. 634. The best keys are made of forged steel, nickel-plated. The portion of key marked *A* is called the "bow," *B* is the "shank," and *C* the "bit." The notches on the edge of the bit at *E* are made to fit the levers, and the notches at *F* show that the key-hole is protected by wards. For locks with a projection on the edge of the key-hole, the key has a groove in one side of the bit to fit the projection, as shown in Fig. 632.

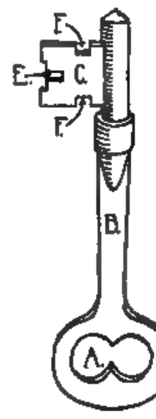


Fig. 634. General Type of Key for Tumbler-Locks.

380. WROUGHT-METAL LOCKS. About the year 1897 locks made entirely from wrought material were placed on the market; these locks were made by machinery and were interchangeable in all their parts. They appeared at the time to mark a new step in the improvement of the ordinary lock, but this did not eventually prove to be the case. Wrought-metal locks have not proved satisfactory and are now little used except in a few of the cheaper grades and in some rim-locks. The Yale "Vulcan" * locks were, to the author's best knowledge, the only locks that were made entirely of wrought metal, but their manufacture has now been discontinued and they are very little used. In these locks the case was pressed from cold-rolled steel, ribbed to give greater strength and stiffness. The posts and guides were riveted to the case, as was also the front.

The author understands that the Russell & Erwin Manufacturing Company was the pioneer in placing on the market a wrought-metal mortise-lock. The manufacturers claim for it a large sale.

Fig. 635. Yale Lock, Type No. 1500.

In the "No. 1500" * mortise knob-lock (Fig. 635), the front, bolts, strike and 5/16-inch hub are of bronze. The fronts can be furnished cast flat, beveled or rabbeted.

* Manufactured by the Yale & Towne Manufacturing Company, New York City.

The back-sets are regular but can be furnished special up to 6 inches. The latch-bolt is either the easy-spring, anti-friction or gun-spring hub-type. The flat front is suitable for use on doors of either hand, and can be furnished with a dust-proof strike at additional cost; if the beveled or rabbeted fronts are wanted the hand of the door must be specified. The case is of japanned iron.

381. GRADES OF LOCKS. The value of a lock depends much upon the way in which the parts are planned, and as no two manufacturers use exactly the same arrangement, it is difficult to compare locks of different makes without considering them in detail. Nearly every manufacturer, however, makes different grades * of locks, which may in general be described as follows:

First and cheapest grade: iron face and bolts, steel springs and a cast-iron or steel lever; iron or steel key.

Second: locks with brass or bronze face and bolts, all the rest of iron, one lever; nickel-plated steel key.

Third: locks with bronze-metal front and strike, bronze-metal bolts, wrought-steel inside works and nickel-plated forged-steel key; this is probably the best grade of the one-tumbler locks.

Fourth: same as the third, with two, three or four levers; usually each grade is made in 3½ and 4-inch sizes for inside knob-locks.

As a rule, a 4¼-inch lock of the fourth grade with three levers is as good a lock as is needed for the inside doors of dwellings. Of course, even in this grade there are differences between the locks of one manufacturer and those of another, and also between a cast lock and a high-grade machine-made lock, the cast lock being considered the better. A lock that is made with fifty "changes" in the gatings is also to be preferred to one with only twelve or twenty-four changes, as there is less chance of any two keys in the building being alike.

For heavy doors, especially in office-buildings, an antifriction latch may be specified, although this latch does not appear to be as much used as formerly. When greater security than that afforded by a three-lever lock is desired, a "cylinder-lock" should be specified. Every large manufacturer has different grades of locks, varying in quality and price, in these four divisions.

382. VARIETIES OF LATCHES AND TUMBLER-LOCKS. Tumbler-locks are made in a number of different styles or patterns to suit different purposes. These are classified as follows:

* "Grade" is taken by the trade and manufacturers to mean difference in quality and strength of workmanship as well as quality and strength of materials and size of lock. The workmanship and quality of material for the same type vary with different manufacturers.

Knob-latches, knob-bolts, dead-locks or dead-bolts, store-door locks, knob-locks and latches, three-bolt chamber-door locks, communicating-door knob-latches with thumb-bolt, communicating-door knob-locks, front-door and vestibule-locks, master-keyed locks, hotel-locks and sliding-door locks.

Dead-locks and knob-locks are made both rim and mortise; rim knob-locks are made also with thumb-bolts, but the other varieties are usually found only in mortise-locks.

Front-door, store-door and the common mortise knob-lock and latch may be obtained with either plain or rabbeted fronts; but the other patterns are made only with plain fronts, except that sliding-door locks are made with astragal-fronts. Front and store-door locks should have the front beveled to fit the edge of the door. A rabbeted lock is made in the same manner as a plain-front lock, except that the front is rebated, as in Fig. 644, to fit the rebated edge of the door. Rebated locks are used only on double doors, and are necessarily made in right and left hands.

383. KNOB-LATCHES, KNOB-BOLTS AND DEAD-LOCKS. The following is a convenient classification for these hardware fixtures:

1. *The Knob-Latch* (Fig. 636). This contains only the latch-bolt and its accompanying mechanism, operated by knobs and a spindle, and is used only where a lock is not desired, as on closet-doors.

2. *The Knob-Bolt.* This form (Fig. 637), contains a simple dead-bolt operated by a thumb-knob from the inside of the door. It is frequently used on outside doors and chamber-doors for additional security, as it cannot be picked from the outside. It often takes the place of the common surface-bolt on account of its neater appearance.

3. *The Dead-Lock* (Fig. 638). This is a simple lock without a latch, and is operated from either side of the door by a key. It is used principally on store-doors, double-action doors, and where an additional lock is desired. For store-doors a lock with a wide bolt and at least three tumblers should be used.

384. STORE-DOOR LOCKS (Fig. 639). The regular store-door lock consists of a case containing a strong dead-bolt operated from either side of the door by a key, and also a latch operated independently from either side by a thumb-latch. By the thumb-latch and handle heavy doors can be more easily swung than by knobs, and as, usually, the door is locked at night only, a spring-bolt is not necessary. Store-door locks of the better grade are fitted usually with "cylinder-escutcheons." The locks are made in several sizes, and may be had with stop-work which, when set, "dogs" the outer thumb-latch so that no one can enter without a key, while those inside may leave freely. A store-door lock with stops is practically a front-door lock operated by a thumb-latch

instead of knobs; it is often used on outside doors for churches, and for residences also. This same type of lock made with a hub

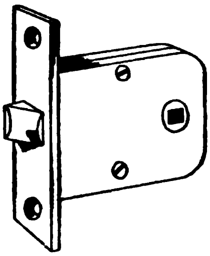


Fig. 636. Knob-Latch.

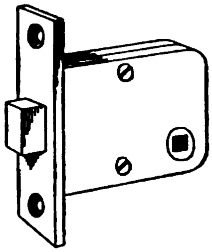


Fig. 637. Knob-Bolt.

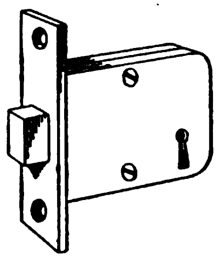


Fig. 638. Dead Lock.

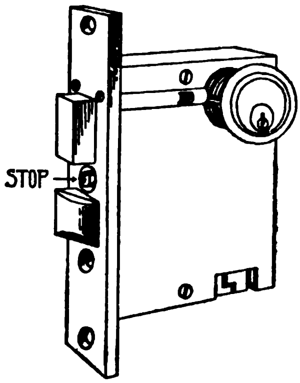


Fig. 639. Store-Door Lock.

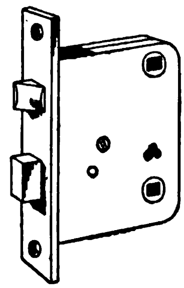


Fig. 640. Knob-Latch with Thumb-Bolt.

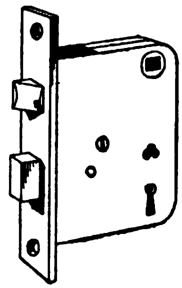


Fig. 641. Knob-Lock and Latch.

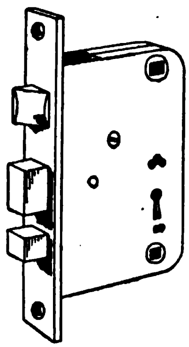


Fig. 642. Three-Bolt Chamber-Door Lock.

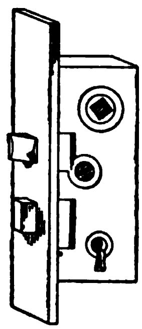


Fig. 643. Up-right Lock.

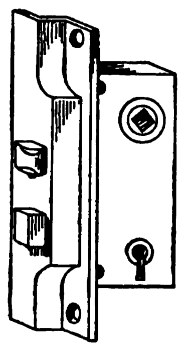


Fig. 644. Rebated Front Lock.

and operated from the inside by a knob, is frequently used on the front doors of residences. The lock shown in Fig. 639 is used

with sectional door-handles. This type is used also on stores and school-houses.

385. THE KNOB-LOCK AND LATCH. (Figs. 640 and 641.) This is the common form of lock and latch generally used on inside doors; the mechanism is described in Arts. 369 to 379. Aside from the quality and mechanism, the variations in this lock consist principally in the size of the case and in the "back-set." In the common sizes the case varies in height from 3½ to 5½ inches; in width, from 2¼ to 5⅝ inches; and in thickness from ½ to ¾ of an inch. The large sizes should be specified for heavy doors.

The "back-set" is the distance from the edge of the door to the center of the hub. This distance varies in different makes of locks, and each manufacturer makes locks with different back-sets to suit different conditions; the distance is given always with the description of the lock. The more common back-set is 2¾ inches, although on 3½-inch locks it is often but 2⅜ or 2½ inches. For doors with a narrow stile an upright lock (Fig. 643), with a back-set of but 1⅞ inches or even 1 inch, may be had. When the back-set is less than 1⅞ inches, however, a lever-handle should be used. If the stile of the door is very wide, a lock with a back-set of 3 inches may be had; this will give greater clearance between the hand and the door-jamb. When designing an ornamental door, the back-set of the lock and also the size of the knob and escutcheon should be considered, in order that they may come well on the door and not be too wide for the stile or interfere with any moldings.

386. THE THREE-BOLT CHAMBER-DOOR LOCK. This lock, Fig. 642, is an ordinary knob-lock and latch with an additional bolt below the key-bolt; the additional bolt is operated from the inside by a thumb-knob. This is a very desirable lock for the chamber-doors of private residences.

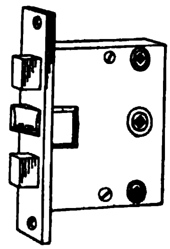


Fig. 645. Communicating-Door Latch.

387. COMMUNICATING-DOOR LOCKS. For "communicating doors," that is, doors between two chambers or offices, two types of locks are used. The simplest, and cheapest, is the communicating-door knob-latch (Fig. 645), which has a latch-bolt and two dead-bolts. These bolts are operated by thumb-knobs, one on each side of the door, so that the door may be perfectly secured from either side. This lock may also be used for water-closet doors between rooms. The other type is the communicating-door lock (Fig. 646), which is a knob-lock and latch with the addition of two dead-bolts operated one from each side of the door.

The advantage of this lock over the latch is that the door may be locked with a key, so that occupants of the two rooms cannot communicate with each other without picking the lock. It is particularly adapted to communicating doors of hotels and lodging-houses. Several other forms of this lock are made, one with an emergency-key for use in opening the door if necessary; and another which is especially adapted for use on the interior doors of colonial residences.

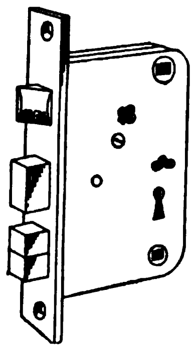


Fig. 646. Communicating Door Lock.

All standard manufacturers make a mortise knob-lock with two key-bolts, operated from disconnected key-holes, so that when locked from one side it cannot be unlocked from the other. This lock differs only from the one shown in Fig. 645 in that the bolts are operated by a key instead of a thumb-piece; an advantage, in some cases.

388. FRONT AND VESTIBULE-DOOR LOCKS. The usual tumbler-lock for front doors differs from the ordinary lock and latch in that it has a swivel-spindle and a stop-mechanism. The swivel-spindle allows the knobs to turn independently of each other, and by means of the stop-mechanism the outer knob may be set, so that the latch can be operated from the outside by a key only, while on the inside it can readily be drawn by the knob.

The dead-bolt is operated by a key from either side as is the case with inside locks. There are thus two key-holes on the outside and one on the inside of the door. Usually the latch and bolt-keys are different. The Yale "Standard" * front-door lock is made so that both the latch and the bolt may be operated by a single key. This type of lock is also now made with one key-hole through which a single key operates both bolts; one turn works the dead-bolt and a second the latch-bolt. All front-door locks are fitted with split-hub spindles. For front doors also a double-throw lock is made, in which the double-throw is accomplished by a second turn of the key. A store-door type of lock, known in the manufacturers' catalogues as "No. 428," * is much used on the front doors of residences. It is operated by a thumb-piece and handle from the outside and by a knob from the inside.

Vestibule-doors of residences should be fitted with a "vestibule-latch" made to match the front-door lock and operated, when the outer knob is set, by the same latch-key; the latch is similar to the front-door lock except that the dead-bolt is omitted.

At the present time the front and vestibule-doors of nearly all

* Manufactured by the Yale & Towne Manufacturing Company, New York City.

first-class residences are trimmed with "cylinder-escutcheon" locks. In these locks the latch and dead-bolt of the front door and the latch of the vestibule-door are operated by one small key.

Fig. 647 shows the general appearance of the "Yale Paracentric" * front-door lock and its corresponding vestibule-latch; the "Yale" * lever tumbler-lock differs from this only in the locking-mechanism. This is the general or "Yale"-type of cylinder front-door lock and vestibule-latch made by all the standard manufacturers. The locks of this type made by Sargent & Company have a protected and adjustable beveled front which is readily adjusted to fit any bevel for either right or left-hand doors. This type of lock is used for double front doors, inside doors of offices and public buildings, school-houses, etc. The type used for school-houses is called "safety," as it can always be operated from the inside without the use of a key.

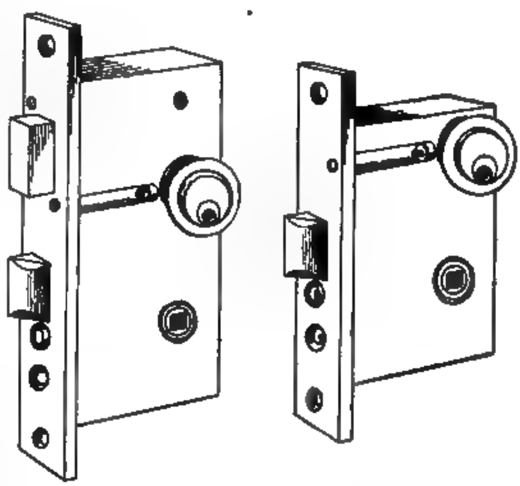


Fig. 647. Yale Front-Door Lock and Vestibule-Latch.

389. UNIT LOCKS AND UNION-LOCKS. As now made by the several manufacturers, these locks are a combination of lock, knobs and escutcheons assembled together and comprising the complete equipment, ready for applying, for both sides of a door. Very little cutting is required in placing the lock-set upon the door. These sets are adjustable for doors from $1\frac{5}{8}$ to $2\frac{1}{4}$ inches thick. In most cases the key-hole is in the knob.

Fig. 648. Unit-Lock Set.

Fig. 648 shows the construction, style, and method of application

* Manufactured by the Yale & Towne Manufacturing Company, New York City.

of a lock of this kind. P. & F. Corbin were the first manufacturers to place a lock of this type upon the market. The Yale & Towne Manufacturing Company, and the Russell & Erwin Manufacturing Company, make locks of this type under permit from the patentees, P. & F. Corbin. The "Sargent" union-lock is for the same purpose, and is somewhat similar in its action to the unit lock.

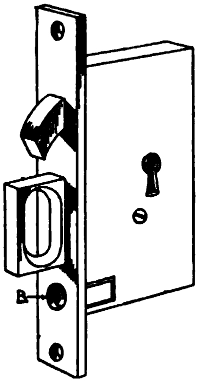


Fig. 649. Sliding-Door Lock.

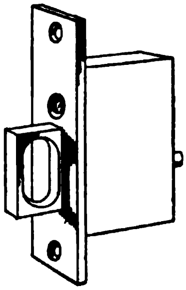


Fig. 650. Sliding-Door Pull.

390. SLIDING-DOOR LOCKS AND PULLS. The common form of sliding-door lock shown in Fig. 649 has a curved bolt which is operated from either side by a key. The flush pull is pushed into the case when the door is closed, or it may be pushed in by hand; it is thrown out by pushing in the button *B*. The locking-mechanism is usually quite simple, as great security is not required for sliding doors of residences.

All manufacturers make a form of sliding-door lock and also a sliding-door night-latch that offers as much security as any lock and may be master-keyed with other locks. They also make locks, with bolts operated by thumb-pieces, for communicating sliding doors. Sliding-door locks for double doors are made with either straight or astragal-fronts.

Locks for sliding doors are also made with an easy-spring latch-bolt operated by knobs and locked by a key. Knobs, however, cannot ordinarily be used on sliding doors, as they would strike against the door-casings. The ordinary trim for sliding doors is the "cup-escutcheon," using an extension or jointed key that will not project beyond the face of the door. If a lock-bolt is not deemed necessary, a simple "flush pull" (Fig. 650) with blank escutcheon-plates may be used.

Special elevator sliding-door locks are used in loft-buildings and, of course, give greater security than the ordinary sliding-door lock made for residence-use.

391. MASTER-KEYED LOCKS. In office-buildings, hotels and lodging-houses, it is desirable that the person in charge shall be able to enter any room, when not occupied, by means of a single key that will operate all of the locks, while the regular keys shall not be interchangeable. Locks made on this principle are termed

"master-keyed locks." The master-key operates all of the locks in the set, while the "change-key" will operate only the lock for which it is made.

All of the better grades of mortise knob tumbler-locks and most cylinder-escutcheon locks can be had master-keyed at a slight advance in price. The method adopted for master-keying differs with different makes and grades of locks. In the cheaper grades master-keying is accomplished by merely introducing different wards or obstructions, either in the key-hole or in the path of the key, and making a skeleton key that will pass these obstructions. Such locks offer little security. Another method is to have different key-holes for the master-key and the change-key.

The best grades of tumbler-locks are master-keyed by means of auxiliary tumblers, which, when raised to the proper height by the master-key, also set the remainder of the tumblers and enable the bolt to be shot; while the change-key does not act on these auxiliary levers and must be bitted for each lock to correspond with the combination of levers, and hence will not interchange. Each lock, therefore, has all the security of an ordinary three-lever lock. Such locks, however, require careful adjustment and excellent workmanship, and are, therefore, somewhat expensive. Master-keyed tumbler-locks are made in sets of from fifty to three hundred, and by using different sets with different master-keys, as many as four thousand changes may be had.

Cylinder-escutcheons also may be master-keyed in sets, with a grand-master-key and an emergency-key.

Two of the systems of master-keying most used are the Yale "duplex" and Yale "bicentric" master-key systems, which consist in every instance of two "Yale" cylinders acting upon one and the same bolt. This gives two key-holes to each lock; the lower ones for the master-key are set to the same combination throughout the suite while the upper ones are all different. By this system all of the security of the "Yale" cylinder is retained, in fact the security is doubled, and the wear is cut in half. A single master-key can be made to pass a series of locks of an almost indefinite number of changes.

In the P. & F. Corbin system of master-keying, when the service or change-key is inserted and turned, the key-plug alone rotates, but when the master-key is inserted the plug and master-ring are locked together and both rotate, operating the cylinder. This gives all the security and independent action of two separate cylinders but necessitates the use of only one, with a single key-way. This is claimed as a distinctive feature by the manufacturers. The regular cylinder is similar except for the

omission of the master-ring. Either five or six pins are employed. The balls at the bottom of the pin-pockets are also a feature of this system and add to the ease with which the key may be inserted or withdrawn. The shape of the key-way prevents the insertion of flat picking tools.

Sargent & Company has a good system which uses but one cylinder. The cylinder has the usual key-plug with a surrounding sleeve, which, when operated by the master-key, makes, with the regular plug, an enlarged plug acting upon another set of pins. This is called the "duplex" system. They also have the "apartment-house" and "block-safety" systems. In the "apartment-house" system one or more locks, at the entrance for instance, can be operated by the keys of all the corridor-locks in the building. The "block-safety" system consists of many sets of cylinders. Each set has key-ways all alike but differing in cross-section from the key-ways of every other set, and is so constructed that the regular key, master-key, or grand-master-key of one set will not enter the key-way of any of the other sets. The cylinders of each set may be master-keyed and grand-master-keyed as usual. If desired, such block-safety sets, having two or more of these special cross-section key-ways, can be arranged with a grand-master-key that will pass all, or they may be grand-master-keyed in sets by themselves and a great-grand-master-key furnished to pass all of the sets. This system is especially adapted for large buildings where the locks are all set up by floors, wards, etc., and where the keys of one group must not enter the key-ways of any other group.

392. MASTER-KEYED LOCKS FOR ASYLUMS AND UNIVERSITIES. 1. *For Asylums.* These locks are constructed for use in hospitals for the insane. They have three bolts, two dead-bolts and a latch-bolt. Each dead-bolt is operated by a separate key which is in the control of a day and a night-watchman. These locks are master-keyed by floors and the entire building is grand-master-keyed. There is provided also a lock-out-key, which, when operated, will lock against all keys. The lock is still further provided with a great-grand-master-key, whose function is to operate the lock at any and all times, even though it has been locked with the lock-out-key.

2. *For Universities.* This is a cylinder-lock, for use on bath-room doors, in case rooms are arranged in pairs with connecting bath. The lock is operated by a change-key, a master-key, a grand-master-key, an emergency-key and shut-out-key. It is also operated on the bath-room side by a thumb-piece. When locked on the bath-room side it is possible for the student to obtain admission by use of his key from the room-side. He can also, when retiring

at night, so operate this lock that it will lock the bath-room door against the student on the opposite side. The master-key performs the usual functions, the lock-out-key locking against all keys and being used for the purpose of locking up the bath-room on one or both sides, should one or neither of the students desire the use of the bath.

393. HOTEL LOCKS. The especial requirements of hotel-locks are that they shall be master-keyed and so arranged that while they may be secured from the inside, the occupant cannot possibly be locked in. The best hotel tumbler-locks have three bolts, a latch-bolt operated from either side by knobs, a key-bolt operated from the outside only by both the "change" or room-key and the master-key, and a dead-bolt operated from the inside by a thumb-piece. The dead-bolt cannot possibly be operated from without, and when the door is locked from within a curtain is thrown over the outer key-hole so that the key cannot be inserted.

Some hotel-locks are provided with an "emergency"-key which operates all locks on all room-doors in the hotel from the outside, even when locked from the inside with the "guest-key" in the lock. This key is designed exclusively for the use of the owner or manager and is kept in a secure place, accessible only to him; it is intended for use only in case of great necessity, such as fire, sickness, etc. This key can also be used to lock the door so that it cannot be opened by either the guest, master or grand-master-keys.

For the cheaper class of hotels a common three-bolt chamber-lock, master-keyed, or a common knob-lock and latch, master-keyed and locked from the inside by the change-key only, is commonly used.

To attempt to describe all the hotel-locks, their operations and special functions, would occupy more space than can be given them. Some locks not generally described as hotel-locks are used for that purpose, and also many cylinder-locks with special functions, for room-doors.

394. CYLINDER LOCKS. This term is now quite generally used to designate those locks in which the bolt or latch, or both, are operated by means of a cylinder-escutcheon which is really separate from the lock proper. The first cylinder-lock or escutcheon was invented by Linus Yale about the year 1860, and for a number of years the "Yale" lock was the only cylinder-lock on the market. The great success of this lock has led to the adoption of somewhat similar cylinders by other lock-manufacturers, and as a result there are now four or five cylinder-locks in common use.

The original "Yale" lock had a small flat key and a small narrow slit for the key-hole. About the year 1880 a corrugated key

and key-hole was introduced, which further increased the security of the lock and the possible number of changes. This has in turn been superseded by the "Yale" paracentric escutcheon, which represents the highest development in key-locks. The construction and operation of this escutcheon, and also the general principle of cylinder-escutcheons, are shown in the illustrations, Figs. 651 and 652.

Fig. 651. Yale Paracentric Escutcheon.

It will be seen by reference to the figures that there are two barrels or cylinders, one rotating within the other, but eccentric with it. The lower cylinder is held from rotating by five sets of round pins, each set consisting of two pieces as shown in the section. When the key is drawn the pins are forced down into the lower cylinder so that it cannot be turned, but when the proper key is inserted in the lock all the pins are raised so that the joint in each set will just come on a line with the top of the lower cylinder, and the cylinder can then be rotated. A cam on the back of the rotating cylinder works the bolt in the lock.

Fig. 652. Section of Yale Paracentric Escutcheon.

It is evident that as the inner cylinder is exactly fitted to the bore in the shell, an almost imperceptible variation in the height to which any one of the pins is raised will prevent the plug from turning; whence it follows that an immense number of locks can be made with such mechanism without duplication.

This arrangement of cylinders and pins is identical with that of the original "Yale" lock, the later improvements being in the shape

of the key and key-hole. In the original "Yale" lock the key-hole was a narrow vertical slot, and it was possible for an expert lock-picker to open the lock by tilting a key or pieces of wire up and down in the key-hole until the pins were brought to the proper position for opening. To prevent this the corrugated key and key-hole was devised, and the new paracentric escutcheon is so constructed that it is impossible to insert any but the proper key in the key-hole or to use any picking-instrument to operate the tumblers vertically, for the shape of the key-hole shown on the face, Fig. 651, is continuous throughout the length of the lock.

An incidental advantage resulting from this change in the key-hole is that, as it differs absolutely from every predecessor, no key heretofore made can enter one of these locks. The paracentric key is also a very difficult one to make, and the blanks can only be obtained from the manufacturers, hence the difficulty in duplicating a key.

As before stated, the standard manufacturers all make the "Yale" type of cylinder-lock in its various forms. These locks offer greater security against picking or accidental interchange of keys than tumbler-locks, and are therefore considered as the best lock for front doors, office and store-doors, drawers, lockers, and wherever special security is desired. A secondary advantage possessed by these locks is the smallness and convenient size of the key.

395. OFFICE-LOCKS. It is generally desirable that the outer door of offices shall be fitted with a cylinder escutcheon-lock. A cylinder-latch with stop-work similar to the vestibule-latch (Fig. 647) is believed to be the most convenient lock for an office-door. A door fitted with this type of lock can be fastened from the outside by any one leaving the office without the delay occasioned by the use of a key. To prevent any instrument from being forced through the wooden stop of the door-jamb to the beveled edge of the bolt, thus forcing it back, the "Yale" and various other types of protected strikes, Fig. 653, have been introduced and give to the latch all the security of a dead-bolt. This strike is applicable to all latch-bolts, but must be made to order to correspond to the exact thickness of the door. All the leading manufacturers make a special office-door latch with a supplemental bolt which automatically locks the main

Fig. 653. Yale Protected Strike.

latch when the door is closed, so that it cannot possibly be forced back. In important office-buildings all of the office-doors are master-keyed.

Another arrangement for office-doors, preferred by some, consists in the use of a good three-tumbler lock together with a supplemental cylinder, rim, night-latch, which may be changed or have a new cylinder inserted when there is a change of tenant. The advantage of this is obvious, as keys are often furnished in duplicate, are lost by the tenant, or not returned when the office is vacated, so that some unknown person might have access to it. By changing the lock such a possibility is avoided. If, however, a single mortise cylinder-latch is used, the same result may be obtained by purchasing a new cylinder; the cylinders of most of the manufacturers are interchangeable.

396. NIGHT-LATCHES. These consist of a latch operated from the outside by a key, and from the inside by a thumb-knob or slide. A stop is provided always for holding back the latch when desired. They are made both rim and mortise, but the rim-locks are used generally for the reason that they do not weaken the door and are more easily applied.

Night-latches are very extensively used on office-doors, club-house doors and the rear outside doors of residences. They are used in addition always to an ordinary knob-lock and latch. As they are used principally to give greater security, it is hardly worth while to put on a tumbler-lock; hence nearly all the night-latches now used have cylinder-escutcheons. For ordinary purposes rim night-latches are finished in black japan or plated finishes, but bronze-metal cases are made for rooms where an ornamental finish is desired. The better grade of rim-locks have the striking-plates and front plate of the lock extended so that they may be screwed to the jamb and edge of the door; thus, to force the door, it would be necessary to break the woodwork. Several manufacturers have a cylinder, rim, night-latch which is made so that no screws are exposed when the door is closed; the case is attached to the door by an interlocking back-plate screwed to the door and by two screws in the edge of the door, or by screwing the lock-case to the inside of the door. Rim night-latches may be used on either right or left-hand doors, but if the door opens outward a reverse-bevel is required.

Several types of night-latches are made as follows: *a,* with stop to hold the bolt back; *b,* with stop to hold the bolt back and to dead-lock it out; *c,* with double-throw bolt giving greater security because of the long bolt, the second turn of the knob or key dead-locking the bolt which may also be held back or operated by a key

from the outside; *d*, with lever instead of knob to pull the bolt back, and stop to hold back or dead-lock the bolt; *e*, with guarded bolt, stop as in *b*; in this case when the door is closed the bolt cannot be forced back. Fig. 654 shows one type* of unit night-latch.

Fig. 654. Russell & Erwin Unit Night-Latch.

397. SPECIALLY MADE LOCKS. Locks with special back-sets; locks with car or swing-latch; locks with special rabbets, beveled or curved or protected fronts; special strikes; electric door-opener attachments; lock-sets trimmed unlike; etc., are furnished by the several manufacturers, usually at an additional cost.

398. DOOR-KNOBS, ROSES AND ESCUTCHEONS. The trimmings commonly used with mortise-locks consisted, until within a comparatively few years, of a pair of knobs, roses and escutcheons.

The rose is a round metal plate made to be screwed to the door and provided with a socket to receive the shank of the knob and prevent its wearing out the lock; it also makes a finish over the hole in the door. The escutcheon is a small plate with a key-hole, Fig. 656, used to make a finish over the key-hole in the door. On outside doors they are often provided with a cover which drops over the hole. Rim-locks are often trimmed in the same way on the outside of the door, but on the inside no rose or escutcheon is needed. These trimmings are still used to a considerable extent in very cheap work, and also in very good work where a special effect is desired. As a general thing, however, the rose

* Manufactured by the Russell & Erwin Manufacturing Company, New Britain, Conn.

and escutcheon are now combined in one long plate, termed an "escutcheon-plate" or a "combined escutcheon," for the reason that a long plate with the screw-holes placed above and below the lock, can be more securely fastened to the door than the rose and small escutcheon-trim, in which at least one of the screws in the rose comes opposite the lock where there is but little wood to receive it.

For ordinary trimmings the long escutcheon also has the neater appearance and the difference in cost is very slight.

As the term "escutcheon" is used to designate both the small key-hole and the long plate for both knob and key-hole, as well as the key-mechanism of cylinder-locks, it is not at all definite when used alone; hence in specifying, either the "combined rose and escutcheon," or the particular catalogue-number of the desired finish should be stated. Many manufacturers have adopted the term "key-plate" to designate the old-style escutcheon, and they make several hundred ornamental patterns with and without covers for the key-hole, for use with glass and metal knobs. The shape of the escutcheon does not as a rule affect the knobs and spindle, that is, on plain goods.

Key-plates are used in good colonial work with both glass and metal knobs. They cannot be used to advantage on thin doors with mortise-locks because of the screws.

399. THE COMMON KNOB, SPINDLE AND ROSE. The common knob, spindle and rose are shown in Fig. 655. The knobs themselves are made of various materials and in different shapes, but all are fitted to a metal shank which receives the spindle. The spindle is the square iron bar which connects the knobs and transmits the knob-motion to the hub of the lock or catch. The common method of attaching the shank to the spindle is by means of a screw (see Fig. 655) which passes entirely through the spindle. There are generally three screw-holes in each end of the spindle to permit its adjustment to doors of different thickness. It is usually impossible, however, to adjust the knob-shanks perfectly by screws alone, and hence small washers are depended upon for close adjustment between the end of the shank and the socket of the rose or escutcheon-plate. The difficulty of getting a perfect adjustment of the knobs so that they will not rattle, and the tendency of the screws to work loose and drop out, have led to the invention of a number of devices for attaching the shank to the spindle without the use of screws passing through the spindle. Although many of these devices are ingenious and possess much merit, but three or four are now used to any extent, and the common square spindle with a screw is still used extensively. The various manufacturers

all have several types of patent spindles. The "Triplex" spindle* consists of three triangular rods which, when united, form a square spindle, to one end of which one knob is permanently pinned. The other knob carries a set-screw which bears on the spindle, as shown

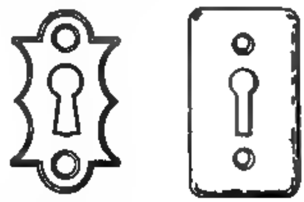


Fig. 655. Knob with Spindle, Screw Partly Covered.

Fig. 656. Key-Plates.

Fig. 657. Swivel-Spindle.

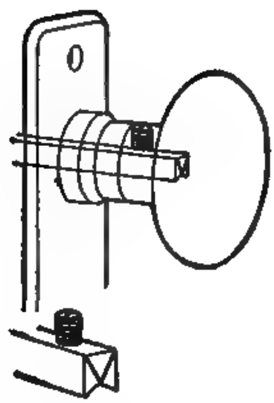


Fig. 658. Yale Triplex Spindle.

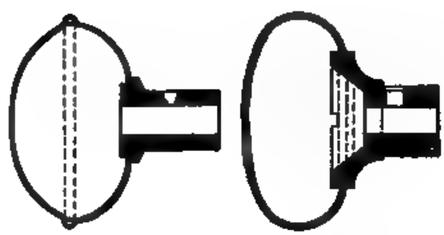


Fig. 659. Spun Knobs.

in Fig. 658. The tightening of this screw forces the spindle into frictional engagement with the knob-shank and holds the knob securely at any point, thus affording perfect adjustment without resort to washers, and eliminating all looseness and rattle of the knobs. All the large manufacturers make various forms of screwless spindles for high-grade work, for use with their cast-bronze knobs, and these accomplish practically the same result as the "Triplex" spindle, although at slightly greater expense. Another

* Manufactured by the Yale & Towne Manufacturing Company, New York City.

manufacturer * makes a ball-bearing spindle to which the knobs are attached by the "screwless" method. This type gives perfect action to the knobs, and eliminates end-play, rattling, binding and slow action.

Front and vestibule-door locks, in which the knobs turn independently of each other, are usually fitted with a swivel-spindle, as shown in Fig. 657. With such locks the outer knob should be fixed to the spindle without screws, otherwise the shank can be removed from the outside of the door, the spindle pushed in and the inner latch-follow turned back.

400. SHAPES AND SIZES OF DOOR-KNOBS. The shape of a door-knob depends somewhat upon the material of which it is made and whether it is a wrought or cast knob. For mineral and cast-metal knobs the more common shapes are the elliptical, the egg-shape and the shape similar to that of a flattened sphere, as shown in Fig. 658. Cast-bronze knobs are made egg-shaped or ball-shaped, and Bower-Barffed iron knobs are also made ball-shaped, which usually adds a little more to the cost. Wrought-metal knobs, bronze and steel, are now made in close imitation of the common shape of cast-bronze knobs. The ordinary shape of wrought knobs is that of the "spun" knob shown in Fig. 659, but wrought knobs are also made in one piece with two pieces spun together at the back close to the shank and they can hardly be distinguished from the cast knob.

"Spun knobs," are made of two pieces of metal shrunk together, and to the shank, as shown. Spun knobs are less expensive than cast knobs. The common sizes of round knobs, whether flattened or spherical, are 2¼ inches for inside knobs and 2½ inches for outside knobs.

401. MATERIALS OF DOOR-KNOBS. The cheapest knobs are made of earthenware, porcelain and various compositions, and are commonly known as "mineral knobs" when of mottled color, "jet knobs" when black and "porcelain knobs" when white. All of these knobs are sold with iron or bronze shanks and roses. The bronze shank is much the better, both in appearance and durability, and should always be specified with these knobs for everything but the most inferior work. A good jet knob with bronze-metal shank and wrought-bronze-metal escutcheon-plate makes a neat trimming for cottages and the inferior parts of larger houses. It is easily kept clean and does not change in color.

Wooden knobs, finished in the natural color, have been used to some extent, and may be obtained in most large cities; they are lit-

* The Russell & Erwin Manufacturing Company, New Britain, Conn.

tle used at present, however. Their shape is usually that of a flat disc, or flattened sphere.

Glass knobs were at one time very popular. Their use, however, became extremely limited, due to the difficulty, formerly, of applying them and to the fact that though they were made hardly good enough for the best work, they were too expensive for ordinary rooms. They are now popular again and extensively used. Pressed glass is used for ordinary work, and cut glass, more or less elaborate in the cutting, for the better class of residences. They are used mostly in the colonial type of residences. Round roses, ornamented on the edge with beads, or plain roses and key-plates are used with them. As the roses used are quite large a 4¼ inch lock should be used in order to have room for the key-plate. These knobs have large shanks and spindles of the screwless type, adjustable for various thicknesses of doors, and are furnished in a large variety of shapes and cuttings by the standard manufacturers. They are made of three general types as follows: a plain round knob of flat form, a plain octagon form, a plain spherical or ball form; and each type is cut in various ornamental patterns.

The common materials for door-knobs at the present are wrought steel, brass, and bronze metal, either wrought or cast. The latter material is susceptible of a great variety of shapes and finishes and of a very high grade of ornamentation. The principal finishes used are described in Arts. 337 to 343. Where the knobs are subject to much wear, a plain round cast knob, natural finish, generally gives the best satisfaction, as it is comfortable to the hand and is easily kept bright. Nearly all of the plated finishes show the effects of wear after a time, although in residences the ornamental goods may be used for a long time without any perceptible change.

Iron knobs, finished by the Bower-Barff or similar process, are much used for public buildings. There are more wrought-steel knobs, in various finishes, sold than any other except the cheap pottery knob.

402. ESCUTCHEON-PLATES. These are now made almost always of steel, wrought or cast brass or bronze, plain, and in the various ornamental finishes. Very large quantities of steel escutcheons are used for cheap work. They vary in size from 5½ by 1½ to 7½ by 2¼ inches for inside doors, and almost indefinitely for outside doors. When ornamented they are usually made in sets, the knob matching the ornamentation of the escutcheon.

The plain escutcheons for 3½ or 4-inch locks are usually interchangeable for the same size of locks, and may be used with jet or porcelain or any plain knob. It is generally necessary, however, to use a knob made by the same manufacturer, for different makes

of locks and escutcheons are not, usually, interchangeable. The same escutcheon will generally fit a 3½, 4 or 4¼-inch lock, though differences may occur in the distance between the key-hole and the knob-hole. Outside escutcheon-plates for tumbler-locks are usually made with covers for the key-holes. Various shapes of ornamental escutcheons are very largely used on colonial work, but are little used otherwise.

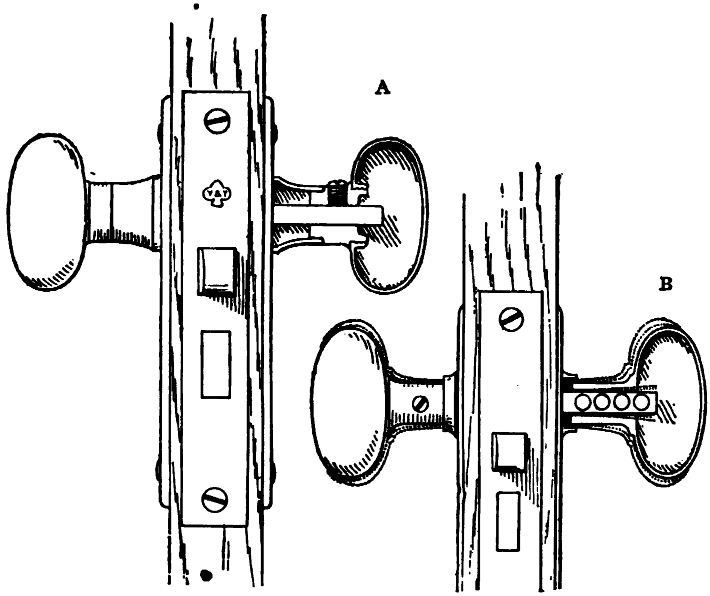


Fig. 660. Details of Knob-Attachment.

Aside from the shape and ornamentation, there is an important difference in escutcheon-plates in the bearing which they afford for the knob-shank. The common type of escutcheon-plate has a very shallow socket for receiving the shank of the knob; this brings the bearing near the surface of the door and permits of a slight tilting motion, as shown by the knobs at *B,* Fig. 660.* The escutcheon-plates, made by one manufacturer * have a long bracket-bearing, as shown in the section at *A,* which supports the knob near the end of the spindle and prevents the tilting-motion. This is the type used generally on screwless-spindle knobs. Fig. 661 † shows the screwless-shank type of knob-mounting. The adjustment to the

* The Yale & Towne Manufacturing Company, New York City.

† Patented and manufactured by the Russell & Erwin Manufacturing Company, New Britain, Conn.

door is obtained by the adjustable shank on the inside knob, the outside knob being fastened to the spindle with a headed pin which is held in place and concealed by the thimble when in use.

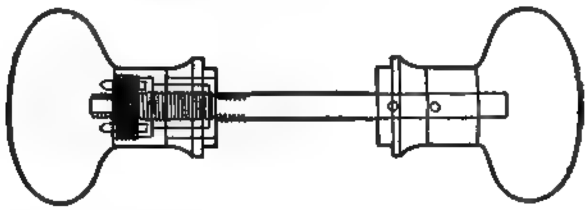


Fig. 661. Russell & Erwin Screwless-Shank Knob-Mounting.

In the case of exceptionally thick doors, an added extension of ½ an inch may be gained by changing the position of this pin in the spindle. For doors of ordinary thickness the extension obtainable by the adjustment of the inner knob will suffice. The method of fastening the knobs, when once adjustment is made, is not dependent upon friction for its successful operation. The pins upon the inner sleeve engage with slots in the knob-shank, and prevent any rotary motion upon the spindle; the outer sleeve and shank are firmly screwed together and it is impossible for the knobs to work loose or to come apart. As the shanks are perfectly fitted to long bracket-bearing thimbles of the supporting type, the closest possible adjustment can be obtained. Screwless-shank knobs are regularly spindled for doors from 1¼ to 2¼ inches thick.

403. HARDWARE IN SETS. Mortise-locks with their trimmings are now largely sold in "sets." A set for a knob-lock consists of one lock, a pair of knobs and two escutcheons. Corresponding sets are made for front doors, sliding doors, communicating doors, etc. The sets are also made up for different grades of locks and for different styles and grades of trimmings. This arrangement permits both the lock and its trimmings to be specified by one number. In selecting goods in sets, however, the architect should carefully read the description of the lock or examine the lock itself, as cheap locks are often put up with very attractive trimmings.

Fig. 662. Loraine Escutcheon-Plate and Knob.

Fig. 662 shows the "Loraine" escutcheon plate and knob with Yale lock. This is one of the many attractive designs made by the different manufacturers.

404. ORNAMENTAL HARDWARE. Within the past twenty years the leading manufacturers of builders' hardware appear to have devoted their efforts principally to the production of artistic designs for the hardware-trimmings of doors and windows, with the result that trimmings of high artistic value of any school of ornament can now be obtained readily, in an almost limitless number of patterns. In fact, the scope of the designs published by the leading manufacturers is so broad and varied as to meet almost every requirement of individual taste or preference, and avoid the commonplace character resulting from a restricted line of inferior designs.

The more highly ornamented patterns are made of cast brass or bronze, plated with gold, silver or copper or left with a natural, sand-finish. Many very ornamental patterns are made also in cast iron, treated by the Bower-Barff or a corresponding process.

By means of various processes, some very attractive hardware is made now of wrought metal. This line is cheaper than the cast hardware, and lacks the delicacy of the latter, but may be used with good effect in cottages and moderate-priced residences. Wrought designs, as now made, are heavier, better in design and are to be obtained in greater variety than formerly. Cast-brass or bronze hardware is better and should be used, unless a cheaper fitting is necessary.

The various ornamentations are grouped by the manufacturer under an appropriate name or designated by letters. Each design usually includes trimmings for the following: front-door knobs, inside-door knobs, round or oval, escutcheon-plates for front and vestibule-doors, inside doors, communicating doors, chamber and bath-room doors with thumb-bolt, cup-escutcheons for sliding doors, push-plates, push-buttons, door-pulls and sash-lifts. Many sets also include store-door handles and escutcheons, lever-handles, drawer-pulls, shutter-knobs, door-knockers, letter-box plates and hinge-plates, so that all of the hardware throughout the building, with the exception of the butts and locks, may have the same ornamentation. Door-knockers are made by several manufacturers and are still in use, especially upon the front doors of houses of colonial design. Lock-fronts, butts and transom-bars are usually left with a plain surface, finished to correspond with the finish of the trimmings. To give an adequate idea of the extent and artistic quality of the product of the different hardware-manufacturers

in a work of this character would be impracticable, even if desirable.

Fig. 663 shows a type of latch and handle often used on the doors of stores and cottages.

Fig. 664 shows an ornamental "Cremorne" bolt. A description of this fitting will be found in Art. 432. (See, also, end of Art. 407.)

405. DOOR-BOLTS IN GENERAL. The greatest security against a door being opened from the outside is undoubtedly obtained by means of bolts operated only from the inside of the door.

The simplest bolts are those which are made to screw to the inside of the door, and of these the most common is the barrel-bolt Fig. 665. The common barrel-bolt, however, has a plain flat staple-plate, and if a staple-plate like that shown in the illustration, which is obviously much stronger, is desired, a "bent staple-plate" should be specified. When made of wrought steel, the bolt shown in Fig. 665 is believed to be the strongest bolt made. Fig. 666 shows a light square bolt, and Fig. 667, a "square-case" bolt, which differs from the square bolt in having a shorter slide, and a closed end to the case. Square bolts of these patterns are not usually over 4 inches long, while barrel-bolts are made 3, 4, 5, 6 and 8 inches long. Small barrel and square-case bolts may be obtained in solid bronze. Cast-iron bolts are not very reliable; being brittle, the bolt or case may be broken.

Fig. 663. Latch and Handle.

Fig. 664. Cremorne Bolt.

Bolts of the above description, however, do not have a very neat appearance in nicely finished rooms, and hence in such places mor-

tised bolts are preferred. The neatest mortise-bolt is probably the knob-bolt shown in Fig. 637, or an extra bolt in the lock, as in the three-bolt chamber-door lock, Fig. 642. When the door is already fitted with a common knob-lock, a cylinder mortise-bolt, of which the well-known "Gem" bolt, Fig. 668, is one of the best examples, may be used to advantage. This bolt is very simple in its mechanism, as shown by the section drawing, and when fully thrown the bolt cannot be pushed back.

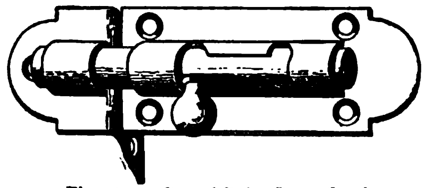


Fig. 665. Barrel-Bolt, Bent Staple.

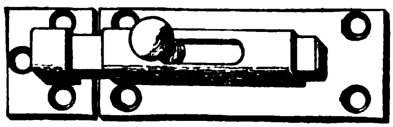


Fig. 666. Light Square Bolt.

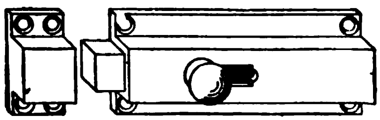
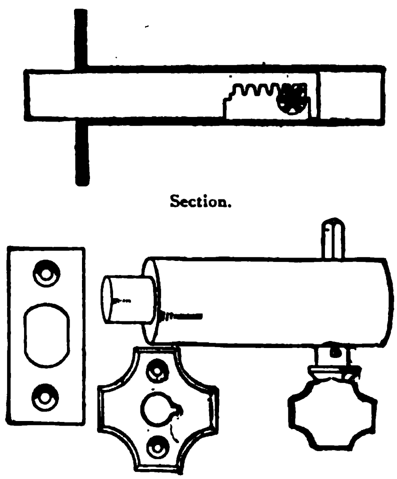


Fig. 667. Square-Case Bolt.

406. CHAIN DOOR-FASTS. These are sometimes used on front doors of dwellings; they permit the door to be opened a few inches to see who is there, but prevent it from being opened further until the chain is removed from the slotted plate on the face of the door.

Fig. 669 illustrates the typical chain-bolt, which consists of a slotted plate to go on the face of the door, and a chain secured to the door-jamb. The chain has a "dog" fastened on the end of it and is made to slide freely in the slot of the plate. A holder is provided to which the chain can be attached when not in use. There are many varieties of these fasteners, all based on the same principle. They are generally of brass or bronze, finished to correspond to the rest of the trimmings.


Section.
Fig. 668. Gem Bolt.

The "Surelock" door-fastener, shown in Figs. 670 and 671,* can be used either as a ventilation-device or as a chain-bolt or inside lock. This fastener

* Manufactured by J. A. Hoegger, Jersey City, N. J.

takes the form of a rigid metal arm set in a flexibly adjusted socket attached to the jamb of the door by means of two screws. The lock-portion of the device, into which the arm is placed when the

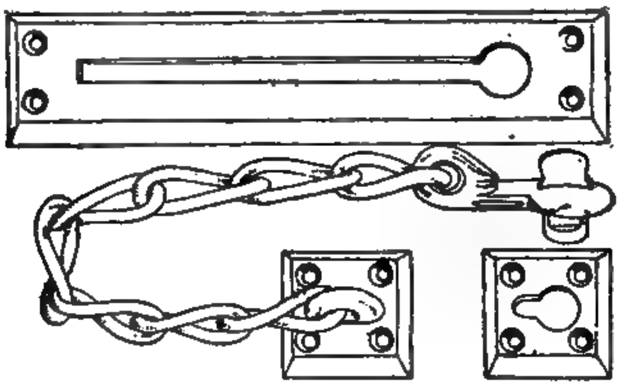


Fig. 669. Chain-Bolt.

locking-device is in operation, is fastened to the door by two screws. The operation of this fastener is shown in the illustrations. It is made of polished brass, or malleable iron in antique-copper finish.

Fig. 670. Hoegger's Surelock Door-Fastener in Use as Bolt or Lock.

Fig. 671. Hoegger's Surelock Door-Fastener.

407. BOLTS FOR DOUBLE DOORS. When doors are hung in pairs, it is necessary to secure one of the doors to the frame by means of bolts, and the other door is locked to it. The common method of securing the "standing leaf" is by means of bolts placed

at the top and bottom of the door. Wherever a neat finish is desired, "flush" bolts generally are used which are either let into the edge of the door or into the inside face of the meeting-stile. When the bolt is placed on the edge of the door it is, of course, inaccessible when the other door is closed and locked; hence the doors cannot be opened without the key. When placed on the face of the door, the doors may be opened from the inside by drawing the bolts and pulling both doors open; usually, however, it is not necessary to secure the door from being opened from within.

When placed on the edge of the door, the bolt is usually operated by a flush thumb-piece, which slides in a slot sunk in the face of the plate. Much trouble and vexation has been experienced with such bolts from the fact that the thumb-piece is usually too small to afford adequate means of pushing or pulling them. This has been overcome by the lever-device, shown in Fig. 672, which, while still flush with the plate, affords a good hold for operating the bolt, and by its long lever-arm enables the bolt to be moved easily under any circumstances. It is used generally by the best manufacturers.

When a flush bolt is used on the face of the door it should have either a good-sized knob, as in Figs. 673 and 674, or the lever-device, shown in Fig. 672. The bolt shown in Fig. 673 * differs from the ordinary flush bolt in having a hooked plate, which adds to the strength both of the bolt and of the door.

Usually flush bolts are not made over 16 inches long, and when the door is over 7 feet high, it is much better to use an extension flush bolt, of which one form is shown in Fig. 674. The extension-bolt differs from the flush mortise-bolt, in that the bolt with its connecting rod is set in a hole bored in the thickness of the door, and the plate in which the knob or thumb-piece slides is only about 6 inches long. The short plate looks much better than a very long plate and does not weaken the door as much by cutting it away. Extension-bolts are made with rods varying from 12 inches to 6 feet in length, and may be used either on the face or edge of the door. When used on the face of the door they are often provided with T handles and turn-knobs. The lengths of both flush bolts and extension-bolts are measured from the center of the slide or lever to the end of the bolt. As a rule 10 or 12-inch bolts are placed in the bottom of the door, and the thumb-piece or knob for the upper bolt should be about 5½ feet from the floor, no matter what the height of the door may be; the difference in the length of the rod adds but little to the cost. Nearly all forms of flush

* Manufactured by the Stanley Works, New Britain, Conn.

bolts are provided with a spring which prevents the bolts from dropping when shot.

The face-plate of both flush bolts and extension-bolts may usually be obtained to match the finish of the knobs and escutcheons, and

Fig. 672. Flush Bolt for Edge of Door.

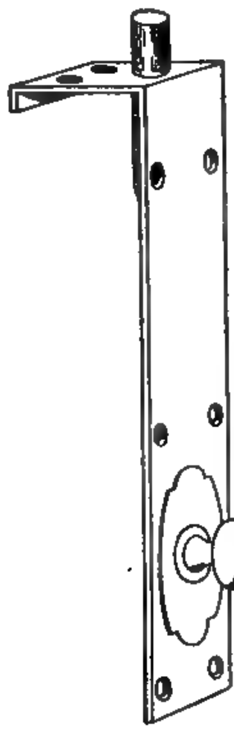


Fig. 673. Flush Bolt for Face of Door.

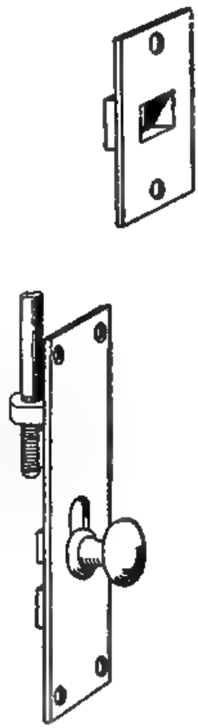


Fig. 674. Flush Bolt for Face of Door.

occasionally the ornamentation. The "Stanley" bolts are all made of wrought steel, planished or polished and plated; most of the other leading manufacturers make their best bolts with bronze-metal plates and knobs.

For store-doors it is customary to use large square bolts screwed to the inside face of the door, the upper or "chain-bolt" being a spring-bolt provided with a chain to pull it down. The lower or "foot-bolt" is made so that the bolt can be pushed down with the foot, while a spring keeps it from dropping when raised. A better and more largely used fitting is the surface top-and-bottom bolt operated by a T handle or lever-handle at the center. For

double-casement or French windows "Cremorne" bolts (see, also, Art. 404, Fig. 664) and "espagniolette" bolts are used in increasing numbers.* Store-door bolts should be of either wrought steel or

A

B

C

Fig. 675. Panic-Exit Door-Bolt or Fastener. A. Double Entrance-Doors, Inside View. B. Unit Lock and Fastener. C. Outside View.

bronze metal. Cast-iron bolts are not desirable, for the reason previously stated.

A special form of flush bolt, known as a "flush Dutch-door bolt," is made for connecting the two portions of a "Dutch door." (See, also, Art. 256.)

408. PANIC-EXIT DOOR-BOLTS OR FASTENERS. This device, shown in Fig. 675,† is somewhat similar to the double-

* These are described at greater length in Arts. 432 and 433.

† Manufactured by P. & F. Corbin, New Britain, Conn.

extension bolt or espagniolette bolt or bar, and is designed for use on the doors of theatres, assembly-halls and all other public buildings. Several forms are made by the various manufacturers. The commonest form has a hinged bar across the entire width of each leaf of the door, at about waist-height, and projecting 2 or 3 inches from the face of the door. A light pressure upon the bar acts upon a spring which releases the upper and lower bolts and the lock, and permits the door or doors to open outward easily and without the delay of unlocking in the regular way. Such bolts are made for use on single or doublt exit-doors, single or double entrance-doors, and corridor-doors, and all open outward. The various manufacturers of these fittings make special locks, latches, door-sets and bolts for use with them.

To lock the door, the key is used in the inside cylinder, which stops the outside knob only. To enter it is then necessary to use a key in the outside cylinder. Each time the door is closed it is locked, until the key is used on the inside to unstop the outside knob. The door is never locked on the inside. Pressure upon the bar on the left-hand door turns the bolts at top and bottom and both doors open at the same time. Pressure upon the bar on the right-hand door opens it by withdrawing the latch-bolt and opens the right-hand door only, the left-hand door remaining closed.

409. TRANSOM-FIXTURES. Transoms over doors or windows may be hung either at the top or bottom by hinges, or pivoted in the center horizontally. If the transom is to be hinged it is generally best to put the hinges at the bottom of the sash, especially over outside doors or windows, as better protection is thus afforded against wind and rain, and there is less trouble from draughts. It is also more trouble to gain entrance through a transom hung at the bottom. There was formerly an objection to hanging large transoms at the bottom, in that if the fixture which held the transom open, gave way, the transom would swing down against the door and very likely break the glass by the fall. Large outside transoms, therefore, were center-hung, or pivoted, with the bottom swinging out. This difficulty has now practically been removed by the use of a device which, according to the claim of its manufacturers,* will absolutely control the transom and eliminate all danger of its falling when hinged at the bottom. This is the "Simplex" lifter, shown in Fig. 676; it is adapted to all types of transoms. It is, however, more difficult to screen a pivoted transom than one hinged at the top or bottom. Transoms over inside doors are more easily operated when pivoted or hinged at the top.

* The Payson Manufacturing Company, Chicago, Ill.

Transoms are of the utmost importance in securing pure air in living-rooms, sleeping-rooms, kitchens, and all rooms where control of heat and ventilation is desirable. Their importance in securing proper air is emphasized in the large number required in the construction of tuberculosis hospitals; and if transoms were more generally used in all homes and living-apartments, there would be less need for such institutions. The awkward control of some years past may have been an occasion for lessening their use in certain types of home-buildings or living-apartments. The use of them should be encouraged and when proper supervision of building-construction is exercised and proper regulation exists, such use will be insisted upon by statute.

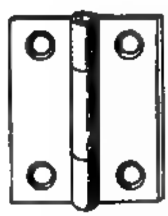


Fig. 677. Narrow Butt.

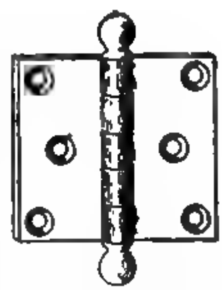


Fig. 678. Narrow Butt, Ball Tips.

Fig. 676. Simplex Transom-Lifter.

Fig. 679. Sash-Centers.

For hanging the transom at top or bottom, 2 or 2½-inch narrow butts, Fig. 677, are commonly used. They may also be obtained with ball-tips, as in Fig. 678, but should have a fast-joint.

When pivoted at the centers of the ends, sash-centers such as are shown in Fig. 679, make as good a pivot as any for transoms of ordinary size. Fig. 680 shows the application of sash centers for sashes pivoted on the sides or at top and bottom. The common

spring window-bolt, Fig. 681, also answers the purpose very well where an especially fine appearance is not necessary. There are also two or three patterns of surface sash-centers. In private resi-

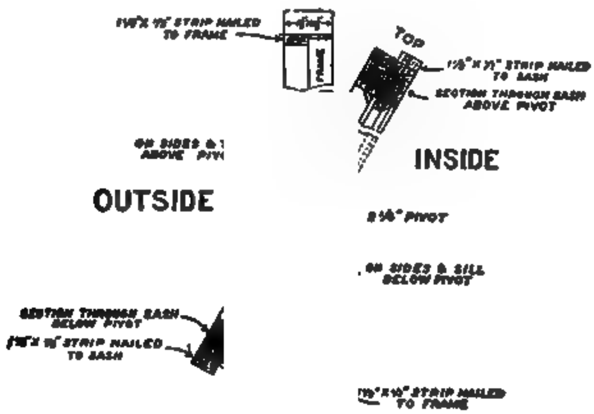


Fig. 680. Detail Showing Application of Sash-Centers.

dences it is well to pivot inside transoms so that they can be readily removed without using a screw-driver.

Small pivoted transoms require only a catch at the top, one with a ring-pull is most convenient, to fasten them when closed, as no special fixture is required to control them when open. Large

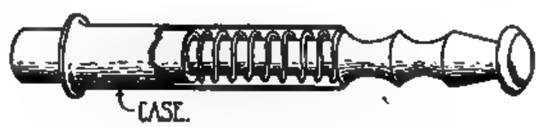


Fig. 681. Common Spring Window-Bolt.

transoms and pivoted transoms over outside doors should be fitted either with a "transom-lifter" or the "sash-adjuster," shown in Fig. 714, Art. 434. One manufacturer * makes a frictional pivot which will hold the transom in several positions with reasonable security. This pivot is only suitable for use on centrally pivoted transoms.

Transoms hung at the bottom are sometimes provided with a "transom-catch," which can be operated by a cord or pole, and with chains attached to the frame or sash which permit the transom to open only a certain distance. This arrangement, however,

* Manufactured by the Yale & Towne Manufacturing Company, New York City.

is not very satisfactory, and it is much better to use a transom-lifter of the "Simplex," Fig. 676, or "Richmond,"* Fig. 682, concealed types, or of the type shown in Fig. 683. There are several

Fig. 682. Detail Showing Application of Richmond Concealed Transom-Lift.

Fig. 683. Transom-Lifter.

transom-lifts of this general type, differing from each other principally in the manner of locking or holding the rod and in the details of their joints. They may be used for transoms hung at top or bottom or pivoted, and may be placed at either side of the door. A transom-fitting called the "Richmond concealed transom-lift," shown in Fig. 682, is entirely hidden in the frame of the door, except for the operating T handle, which is placed upon the jamb of the door at a convenient height from the floor. Among the better types

* Manufactured by the McCrum-Howell Company, New York City.

of transom-lifts that the author has seen, is the Yale. It has two steel grip-plates which are forced against the rod by strong spiral springs and are released by turning a neat thumb-knob. A "transom-support" and lock controlled by a window-hook is also made by the manufacturers of the "Simplex" lifter. Several other manufacturers also make various types of transom-fittings. Common transom-lifters are made with wrought steel rods and cast-iron or steel brackets and fittings, and are finished in bright copper. The better kinds, however, can be had either in bronzed steel or iron, bronze plated in various finishes on steel, Bower-Barff, or in solid bronze or brass to match any style of finish. The stock lengths are 3, 4, 5 and 6 feet, but they can be made up to 9 feet in length if so ordered, with rods of several different thicknesses. For lifters 5 feet long or over, the rod should be 3/8 of an inch in diameter.

410. SCREEN-DOOR HARDWARE. Screen-doors to be effective, must be provided with a spring to close them quickly when opened. This spring may be either in the hinge or separate from it. Where a screen-door is to be in almost constant use, it is best to use a good quality of single-action spring-hinge, such as the "Bommer," having a strong and elastic spring-coil, a simple pull-handle for opening the door, and a hook or bolt for securing it from the inside.

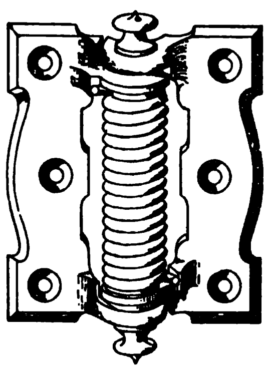


Fig. 684. Columbia Spring-Hinge.

A great many special spring-hinges are made for screen-doors, most of which have the spring-coil exposed, as in Fig. 684. Many of these hinges are made of cast iron, although a few are made of solid bronze or cast brass with brass springs; the latter makes a very serviceable hinge, although for the best residences, stores and offices, the "Bommer," * "Oxford," † "Columbia," † or "Columbian" † spring-hinges in bronze or brass, are to be preferred. When exposed to the weather, steel hinges are apt to rust.

Many of the cheap spring-hinges for screen-doors are so made that when the door is revolved about 135 degrees, the spring holds the door open, instead of closing it. Such hinges are termed "hold-back hinges," and while they are sometimes serviceable,

* Manufactured by Bommer Brothers, Brooklyn, N. Y.

† Manufactured by The Columbian Hardware Company, New York City.

they are not usually so good for closing the door as the type shown in Fig. 684.

For residences it is often more convenient to use a pair of plain butts, either 3 by 3-inch, or 3½ by 3½-inch, with the spring separate. The spring can then be detached, or the tension released at will.

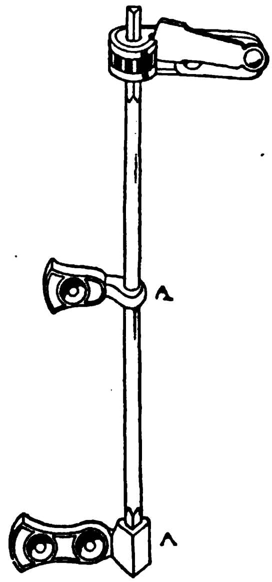


Fig. 685. Torrey Door-Spring.

For separate springs the "Torrey," Fig. 685,* is very extensively used, and works very satisfactorily. The tension is adjusted or released by means of the cogs and catch at the top, a small wrench for turning the rod being furnished with the spring. The "Gem" * or "Star" * coil door-springs are often used in place of the "Torrey" and are made in all finishes, including polished brass. A very satisfactory spring is the ordinary coil door-spring. One end is fastened to the door, the other to the casing, and the tension in the spring is adjusted by a winding-pin. This spring is furnished in several sizes.

The door-spring shown in Fig. 686, which is a strong steel spring-coil about 17 inches long with a hook at each end, also makes a very good spring for screen-doors, as it works well and can be very quickly detached. It is secured to the inside of the door at the top, and to the underside of the top jamb near the side, by screw-eyes.

For the screen-doors of residences a catch with stop-work and knob on the outside and a lever-handle on the inside, makes the most suitable trimming. Such catches are made especially for screen-doors, as a reverse-bevel is always required. One of the best catches that the author has seen is the one shown in Fig. 687.† A very similar flush catch is made by the E. T. Burrowes Company and used on this company's screen doors. The screen-door catches usually found in hardware-stores are very cheap affairs.

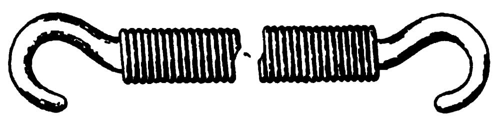


Fig. 686. Coil Door-Spring.

* Manufactured by The Columbian Hardware Company, New York City.

† Manufactured by Sargent & Company, New Haven, Conn.

Mortise screen-door catches are now in general use for the better residences, and are furnished with or without a key. The manufacturers of the catch shown in Fig. 687 also make a mortise

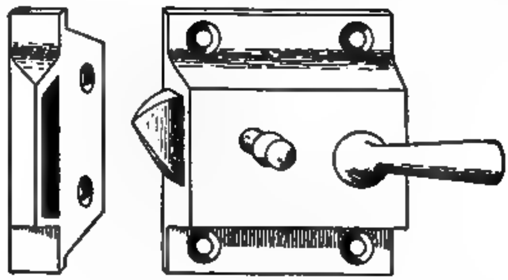


Fig. 687. Screen-Door Catch, Made by Sargent & Co.

cylinder screen-door catch which can be furnished with keys made to pass the front-door locks.

411. WATER-CLOSET-DOOR HARDWARE. Where several water-closets are placed in a large toilet-room, each closet should be enclosed by thin partitions, preferably of marble, about 3 feet apart and from 6 to 7 feet high, with a short door placed in front of the closet. These doors usually are hung with spring-hinges, set to hold the door either closed or open as desired. Single-action hinges are more frequently used, but double-action hinges may be used if desired; with the latter the door is always shut, except on entering or leaving. The single-action hinges are usually "surface" hinges, made to screw to the face of the door and frame, although the "Bommer" and "Draper" spring-hinges may be had with box flange, as in Fig. 688. The standard form of hinge shown in Fig. 688, or some modification of it, can be clamped around the pipe-upright of the partition after the latter has been installed. Most of the better class of spring-hinges are made in patterns especially adapted to water-closet doors. All of these hinges are made with a box flange to fit over the edge of the marble jamb to which they are secured by bolts.

Single Action. Standard Pipe-Hinge.

Fig. 688. Bommer's Single-Action, and Standard Pipe-Hinges.

The "Bommer" and the "Draper" single-action spring-hinges have a box flange with the inside made to adjust ¼ of an inch, to

allow for any variation in the thickness of the marble. Single-action hinges set to close the door, should have a strike with rubber cushion on the jamb for the door to strike against. These may usually be obtained with the hinges. Doors hung with double-action hinges are not usually fitted with any lock or bolt, push-plates only being placed on each side of the door. Doors with single-action hinges should have a pull-handle on one side, and usually are fitted with a bolt on the inside; special "water-closet bolts" are made for this purpose which have an indicator-dial on the outside of the door to show that the closet is occupied when the bolt is shot. Water-closet hardware is now made in great variety, by several manufacturers, for use in hotels, office and public buildings.

412. OFFICE-GATE HINGES. Office gates are fitted usually with spring-hinges. Special wide hinges for such gates are made in the "Bommer" line for both single and double-action. The top rail, however, should not be more than 4 inches wide, when such hinges are to be used.

413. DOOR-CHECKS IN GENERAL. Single-action doors fitted with a spring, whether in the hinge or separate from it, are sure to slam violently, if there is sufficient tension in the spring to close the door; and to avoid this several devices for checking the door while closing have been invented. Double-action spring-hinges are nearly as often used to prevent the slamming of the door as to permit it being opened either way. Double-action doors, however, cannot be made very tight, and are objectionable in this respect for outside entrances. It has been found that the most practical forms of door-checks are those which are attached to the top of the door and frame, and which are known as "overhead checks."

There are two distinct kinds of door-checks: A, those which simply check the door when closed by a spring or by hand, and B, those which both close the door and prevent its slamming. Checks of the former class are used commonly with single-action spring-hinges; those of the latter class are used with ordinary butts. Several styles of door-checks of class A have been patented. The "Eclipse" door-check,* appears to have been the most popular check several years ago, but, as the use of class-B checks has quite generally superseded the use of those of class A, it is not as extensively used as formerly, although still made. It consists of a piston secured to the head of the door-frame and working in a cylinder attached to the top of the door. The piston-rod is attached in such a way that it prevents lateral motion and can be accurately

* Manufactured by Sargent & Company, New Haven, Conn.

adjusted to meet the cylinder. When the door is opened, the cylinder is drawn entirely away from the piston, while the compression of the air in the cylinder when the door closes prevents any slamming. The air escapes through openings in the end of the cylinder, which are so arranged as to be easily regulated. A special spring for closing the door is made for doors hung with ordinary butts.

414. THE DOOR-CHECK AND SPRING. The first devices put on the market, consisting of a spring to close the door and acting in conjunction with a piston and air-chamber, were found to be unsatisfactory for many reasons and at the present time the best-known devices include a non-freezing liquid as the checking-medium. The first successful liquid door-check was the "Blount." * This device is well known, having been largely used during a period of twenty-five years. The "Yale" door-check,† Fig. 690, retains all the desirable features of the old "Blount" door-check and includes, also, many important improvements, which increase its strength and durability. Its mechanism is simple, and based upon thoroughly well-tried principles involving the use of a powerful coil-spring operating upon a drop forged-steel shaft, which at its lower end actuates (through a crank and connecting rod) a piston operating in an hermetically sealed chamber filled with liquid. This type of check offers a minimum of resistance to the opening of the door, while furnishing ample power, under perfect control, for closing it without slam or jar.

Other door-checks, somewhat similar in type and using liquid as the retarding-agent, are the "Russwin" ‡ (which can be applied to either right- or left-hand doors without reversing the spring, which is of the coil-wire type and of great wearing quality), "Sargent," ‖ "Norton," ¶ Fig. 689, and "Corbin," § the last two using a rack and pinion instead of the well-known engine-crank action.

The above-named devices are all used in connection with single-acting doors, but the demand for a checking-device for double-acting doors has been insistent and a few years ago two double-acting door-checks, the "Yale" * and the "Rixson," Φ were placed on the market. Unlike the single-acting checks, these mechanisms have no spring to close the door but are essentially constructed to control double-acting doors, hung on spring-hinges of any type. They do not resist the opening of the door in the slightest degree, but bring it to a gentle, positive stop at center without the annoying oscillation, so common in uncontrolled doors of this type. They are liquid checks constructed upon the engine-crank principle, and have been successfully employed in controlling entrance, vestibule and interior

* Manufactured by the Yale & Towne Manufacturing Company, New York City.
† Brought out in 1911 by the Yale & Towne Manufacturing Company.
‡ Manufactured by the Russell & Erwin Manufacturing Company, New Britain, Conn.
‖ Manufactured by Sargent & Company, New Haven, Conn.
¶ Manufactured by the Norton Door Check Company, Chicago, Ill.
§ Manufactured by P. & F. Corbin, New Britain, Conn.
Φ Manufactured by the Oscar C. Rixson Company, Chicago, Ill.

doors in all classes of public buildings. They may be installed when a building is erected or may be applied without difficulty at any time thereafter.

1 Case or Shell.
2 Top Cap.
3 End Plug.
4 Ratchet.
5 Gland Packing-Nut.
6 Packing-Gland.
7 Packing-Washers for Gland.
8 Piston.
9 Ball Valve.
10 Ball-Valve Retainer.
11 Main Arm.
12 Pawl.
13 Main-Arm Connection.
14 Fore-Arm Stud.
15 Fore-Arm Shoe.
16 Fore-Arm Clamp.
17 Fore-Arm Clamp-Screw.
18 Connecting Rod.
19 Fore-Arm Sleeve.
20 Regulating Screw.
21 Regulating-Screw Washers.
22 Regulating-Screw Bushing.
23 Spring.
26 Shaft and Pivot.
27 Top Nut for Shaft.

Fig. 689. Section of Norton Liquid Door-Check.

The use of checking floor-hinges in public buildings, as well as in apartments and private houses, has developed to a remarkable extent since 1905. It is better to install this mechanism during the construction of a building, as it must be fitted into the floor and necessitates an operation presenting some difficulties if deferred until after the building is completed.

The box containing the mechanism is of cast iron and a very pow-

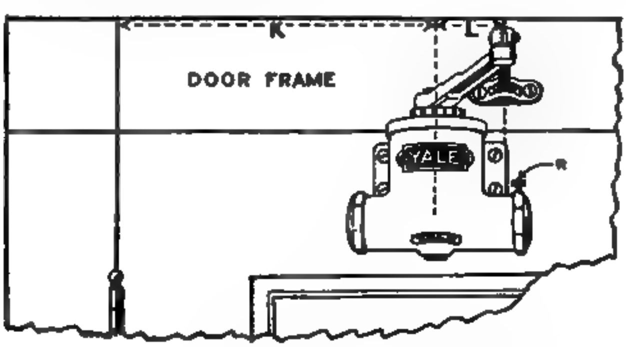


Fig. 690. Yale Liquid Door-Check.

erful spring is provided which acts upon the steel spindle on which the door is carried. The spindle drives a piston of relatively large diameter and a non-freezing liquid is the checking-medium. The important advantages of floor-hinges such as the "Rixson" ¶ and the "Yale," ‖ made for both single-acting and double-acting doors, are that the devices are set into the floor, the top being flush with finished floor-line; butts are eliminated; and the door is promptly and noiselessly closed by a means which is practically invisible. The "Rixson" is built to take care of wind pressure encountered on outside and vestibule doors. It is built with two springs and two pistons all capable of independent adjustment to take care of unequal wind pressure on opposite sides of a door. Paragraph 357, Checking Spring-Hinges, gives further particulars on this subject.

Fig. 691. Empire Door-Holder.

415. DOOR-HOLDERS. Various types of this fitting are made and used on many doors which are fitted with a door-check and spring. They serve to hold the door open when desired. Figs. 691 * and 692 * show the "Empire" and "Caldwell" door-holders.

416. DOOR-STOPS. Many types of door-stops are made by the various hardware-manufacturers. One type called the "Duplex" † stop, is especially suitable for use on double doors. It will also serve as a substitute for double-acting hinges, and by permitting each one of a pair of doors to be opened one way only, compel the stream of travel from each side always to "keep to the right." Each door can thus be hung on regular butts and controlled by a door-check. This is one of the best systems of controlling double-doors in the corridors of hotels, stations, and buildings of all kinds.

Fig. 692. Caldwell Junior Door-Holder.

417. DOUBLE-HUNG WINDOW-SASH HARDWARE.‡ The trimmings or hardware for double-hung windows consist, usu-

* Manufactured by the Caldwell Manufacturing Company, Rochester, N. Y.

† Manufactured by Sargent & Company, New Haven, Conn

‡ Arts. 139 and 141, Chapter III, relating to double-hung window-frames, contain matter which should be read in connection with Arts. 417 to 431 of this chapter.

‖ Manufactured by the Yale & Towne Manufacturing Company, New York City.

¶ Manufactured by the Oscar C. Rixson Company, Chicago, Ill.

ally, of pulleys, sash-cords, chains or tapes, the weights for balancing the sashes, sash-fasts, sash-lifts and sash-sockets.

418. SIDE PULLEYS FOR WINDOW-SASHES. These are of two types, side-pulleys and overhead pulleys. The former is the type commonly employed, and in fact, prior to about the year 1890, was the only type in use.

The general shape of the common side-pulley is shown in Fig. 693, although the ends of the face-plate are as often round as square. These pulleys consist of a cast or wrought-iron frame with a finished face-plate and a cast-iron wheel working on an axle. Side-pulleys are fixed in a mortise cut into the pulley-stile, and the face-plate is usually the only portion that is finished.

Millions of very cheap iron pulleys are used every year, and unless the architect takes pains to specify the particular style and finish of pulleys he wishes used, he is quite likely to get a very inferior article. The essential points of a good pulley are that the wheel should be of sufficient size, and have a durable smooth-running axle with broad bearings, and that on the whole it shall have a neat appearance.

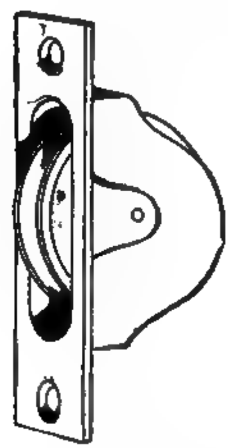


Fig. 693. Ordinary Axle-Pulley. Fig. 694. Norris Sash-Pulley.

The common stock sizes of sash-pulleys are 1¾, 2, 2¼, 2½, 3 and up to 4 inches, the size referring to the diameter of the wheel. (See, also, list of sash-pulley sizes for sash-ribbons, Art. 422.) Special pulleys are made with diameters up to 12 inches. The "Gardner" * pulleys are made up to 3½ inches. The 2-inch wheel is sufficiently large for a sash not exceeding 3 by 3 feet with double-strength glass; but for larger or heavier sashes, larger sizes should be used, principally for the purpose of throwing the sash-cord further into the pocket so as to prevent the sash-weight from striking the back of the pulley-stile. Pulleys 1¾ inches in diameter should not be specified except for very small windows; the manufacturers indeed, advise that none smaller than the 2-inch be used.

For ordinary purposes a "steel axle" may be specified; in the

* Manufactured by the Gardner Sash-Pulley Company, Morris, Ill.

better grades the axles are turned and the pulleys are then called "noiseless pulleys." For pulleys larger than 2 inches, it would be well to specify a gun-metal or phosphor-bronze pin, as these are less likely to break. There are also two or three kinds of anti-friction pulleys. The various grades of steel-axle pulleys run about as follows: plain face and wheel; lacquered or amber-bronze face, plain wheel; bronze-plated face of various finishes, nickel-plated face, Bower-Barff face, bronze or brass face, iron wheel; bronze or brass face, and bronze or brass face and wheel. A bronze or brass wheel would hardly be warranted except in very expensive work.

There are several variations in the shape of side-axle pulleys, but they are mostly in the cheaper grades where special study has been made to reduce the labor of fitting them to the frame. Such pulleys are usually too cheap to specify. The principal variation from the common shape amongst good pulleys, is that of the "Norris" pulley, Fig. 694.* The "Norris" sash-pulleys differ from the ordinary axle-pulleys in the form of their face-plates, as seen in the cut. The face-plate on the lower end is beveled and the upper end carries the screw. The mortise is undercut in the pulley-stile for the lower end of the face-plate, so that when the lower end of the pulley-case is inserted in the mortise, the pulley does not depend upon the screws. This only makes the pulley more secure, as the more weight put on it the more it embeds itself in its mortise. Norris pulleys are furnished with wheels 1¾, 2, 2¼, 2½, 3 and 4 inches in diameter, and the wheels are grooved for either sash-cord or sash-chain as desired. A 2½-inch diameter of wheel for a sash of the usual size and a 3 or 4-inch wheel for an extra heavy sash is recommended. A turned, true wheel with good axle-bearings is very important for the life of a pulley in the better class of buildings.

Sash-pulleys are made by a great many different firms, but only a few make a specialty of the better grades. The manufacturers of the "Norris" pulleys make probably the greatest variety, and several of their grades are of great excellence of construction. They are made for cord, tape or chain, and the chain-wheels have a groove especially designed to fit the usual shape of chains.

The manufacturers of the "Gardner" sash-pulley make a special counterbalance side-pulley for use with the counterbalanced plank-frame windows that are now being used in factories and storehouses. No weights or pockets are required as one sash counterbalances the other. The same manufacturers also make a

* Manufactured by Frank B. Sloan & Company, Baltimore, Md.

large line of sash-pulleys especially adapted to their sash-ribbon, or for rope, chain or cable.

419. OVERHEAD PULLEYS FOR WINDOW-SASHES. These pulleys differ from the side-pulleys in that they are made to apply above the pulley-stile, and necessitate a differently shaped case from that of the side-pulleys. The first overhead pulley, "Shull's," was patented in 1895, and was quickly followed by the "Watson," "McQueen" and "Grant" patents on various types of pulleys; but it is only since about the year 1907 that this type of pulley has been brought to its highest state of perfection. It is now manufactured in all the standard finishes, and with plain, roller-bearing and ball-bearing axles.

The principal advantage of the overhead pulley is that it gives approximately 8 inches more weight-room in the box than the side-pulley, and thus in many instances permits the use of cast-iron sash-weights where the lead weights would be necessary if the ordinary type of sash-pulley was used. Then, too, the wheel is not exposed, and there is no opening to be seen; and the face-plate being mortised into the under side of the yoke, is not as conspicuous as when set in the pulley-stile. In a window fitted with shades, it is hardly noticeable. Overhead pulleys cost no more than side-pulleys of a similar grade. The original and only objection that was offered to the "Shull" pulley was that it required a little more than the usual headroom above the top of the frame. This objection has been met, however, in the later types, and the pulleys manufactured for twin, triple and quadruple frames, where the weights are carried at the ends, and where to give the maximum amount of light service, only 2-inch mullions are allowed, are now in their highest perfection. Fig. 695 * shows the Grant overhead pulley. The construction explains itself. Fig. 696 † shows an arrangement of the Gardner overhead sash-pulleys for two windows and one mullion, and for three windows and two mullions. For twin openings the two single pulleys are not required. The larger the pulley the longer the wear of the sash-cord. Smaller pulleys than those specified in the schedule given in Art. 420 should not be used, and larger pulleys will give still better service.

420. SASH-CORDS. Until a few years ago, linen or cotton cord only was used for connecting the weights with the sashes of double-hung windows, and cord is still more extensively used than either ribbons or chains. For windows of ordinary size a good braided cord will wear for a long time, and this material will probably never be entirely displaced by metal. "Tests made at the

* Manufactured by the Grant Pulley and Hardware Company, New York City.

† Manufactured by the Gardner Sash-Pulley Company, Morris, Ill.

Massachusetts Institute of Technology (see Art. 423) show that cords wear much longer than chains, though they have less tensile strength. Cords should be smooth and round, so that each strand bears its part of the stress, and well glazed, so that they have a

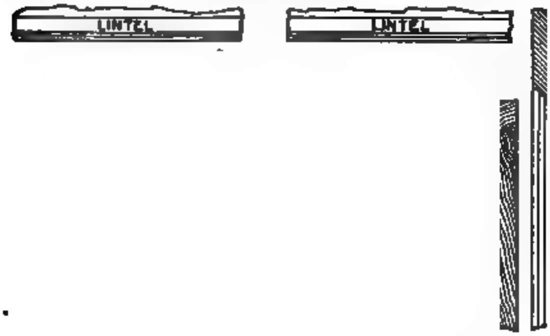


Fig. 695. Grant Overhead Sash-Pulley.

Fig. 696. Gardner Overhead Sash-Pulley.

smooth surface and consequently less wear from friction with the wheel of the pulley."

It has been found that cord can be braided too hard for durability, yet if it is braided so as to be very flexible it may be so soft that it will stretch and cause great annoyance by permitting the weight to hit the bottom of the weight-box.

The architect, however, should always specify the particular

brand and size of cord to be used, and also the diameter of the pulley. Among the leading brands of sash-cord at present are the "Samson Spot," * the "Silver Lake A," † ("A" means the first quality). Both of these are superior to the ordinary braided cords, which are made from inferior yarns to meet the jobbers' requirements for price. In addition to other most excellent qualities, the "Samson" cord offers an additional advantage that architects will appreciate; it has a colored strand woven through it, which shows in spots on the surface and thus enables the architect to tell at a glance that no other cord has been substituted. The Silver Lake sash-cord has the name "Silver Lake A" branded on every foot of cord. The letter "A" is omitted on their second grade. The marking of the cord by color, or any other device does not alter the quality of the cord. Special marks may be applied to inferior cord as well as to the best. The following numbers should be specified for the different weights of sash-weights.

RELATIVE SIZES OF SASH CORD, WEIGHTS AND PULLEYS.

Size number	6	7	8	9	10	12
Diameter	3/16	7/32	1/4	9/32	5/16	3/8
Feet per lb. (Approx.)	66	55	44	36	27	20 ft.
Suitable for weights up to	5	12	20	30	40	50 lbs.
Minimum diam. of pulley allowable	1½	1¾	2	2¼	2½	3 in.

For hanging sashes weighing over 40 pounds, only the largest size of "Samson Spot" or "Silver Lake A" cord, or some form of sash-chain, ribbon or wire cable should be used; and the pulleys should be selected to fit the cord or chain. A guarantee that the cord will last at least twenty years may be had from either of the above manufacturers.

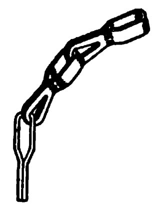


Fig. 697. Monarch Sash-Chain.

Samson Wire Center Sash-cord * is a metal cord with a braided cotton protection which acts as a noiseless cushion. It is claimed that it harmonizes with the window finish and that it has greater durability than any other device. The standard color is dark mahogany, but it is made to order for large buildings in other colors to match the finish.

421. SASH-CHAINS. Of several styles of sash-chains in the market, the style most largely used is the flat-link chain, of which, perhaps, the best pattern is shown in Fig. 697.|| This chain is made

* Manufactured by the Samson Cordage Works, Boston, Mass.

† Manufactured by the Silver Lake Company, Boston, Mass.

|| Manufactured by the Bridgeport Chain Company, Bridgeport, Conn.

either of steel or of bronze composed of 95 per cent copper and 5 per cent tin. For suspending very heavy sashes, doors and gates, the cable-chain, shown in Fig. 698, has been extensively used. Fig. 699 shows the "Star" * brand bronze-metal sash-chain. The drawing shows the connections of chain to sash and weight.

The manufacturers of the "Norris" pulleys claim that a riveted chain having joints only one way is almost sure to break when even slightly twisted, and that it is better to use two chains of the link-pattern running side by side over the same pulley.

The strongest sash-chains are of steel made rust-proof by the hot-galvanizing process, and electro-copperplated to give a bronze finish; and of a bronze mixture which looks like copper, but is tougher and harder. One firm † claims that its galvanized-steel sash-chain is from 11 to 45 per cent stronger than any bronze or copper sash-chain and that it will resist fire for a much longer period. The tensile strength of their chain varies from 475 to 850 pounds, according to the weight used.

Fig. 698. Cable-Chain.

Fig. 699. Detail Showing Devices for Connecting Chain to Sash and Chain to Weight.

422. SASH-RIBBONS. These are now also extensively used in hanging the sashes of the better class of buildings. The ribbons are made of steel and aluminum-bronze or of some mixture of aluminum, and in ⅜, ½, ⅝, ¾ and ⅞-inch widths. They are claimed to be practically indestructible, but according to one series of tests it would appear that in some cases they do not wear as long as sash-cords or sash-chains. Some people object that the ribbons snap against the pulley-stiles, when the sash is raised or lowered, and thus make considerable noise. The ⅜-inch ribbon may be used for a sash weighing up to 100 pounds and requiring 50-pound weights. For a window 6 feet 10 inches high and 3 feet wide, glazed with plate glass, the ribbons with attachments will cost about

* Manufactured by the U. T. Hungerford Brass & Copper Company, New York City.
† The Oneida Community, Ltd., Oneida, N. Y.

properly. If the hooking-device fails near the top the upper sash cannot be closed and if at the bottom the window cannot be opened.

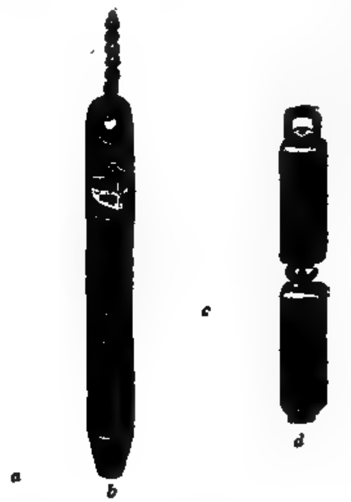


Fig. 700. Types of Iron and Lead Sash-Weights.

It is then necessary to open the weight-box and rehang the sections before the window can be operated. In theory sectional weights are ideal; in practice, however, they are not considered as satisfactory as solid weights. The "Brown" * sectional weight, is made 2¼ by 2⅝ inches and in weights of 6, 7, 8, 9 and 10 pounds. Fig. 700, types *a* * and *b*,* shows cast-iron weights. Types *c* and *d* are lead weights (see Art. 426).

Fig. 700*a* shows various details of weight-boxes for the frames of double-hung windows. The details shown are for square, oblong and round sash-weights.

It frequently occurs after the contract is let, that the glass is changed from double-thick to plate or prism glass. This means increased weight, but the length of the sash-weight cannot be increased

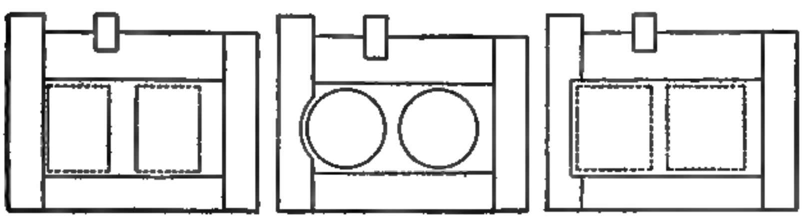


Fig. 700*a*. Details of Weight-Boxes in Window-Frames.

and it therefore becomes necessary to increase the area of its cross-section. If the weight-box is detailed to take the regular round sash-weight, its general construction will be such that it will take a 2-inch round sash-weight, but not a 2-inch square sash-weight. This difficulty can be avoided by a little thought at the start. An

* Manufactured by E. E. Brown & Company, Philadelphia, Pa.

added depth of ¼ of an inch in the weight-box would permit the use of a rectangular cast-iron sash-weight.

Fig. 700*b* illustrates the "Sanborn" sectional sash-weight* which is intended for use in large buildings of heavy construction. Because of the lack of uniformity in the weight of plate glass the required weight of sash-weights cannot be accurately determined previous to the hanging of the sashes. By the use of a sectional sash-weight, combinations of units can be made up to suit the requirements. The units are made square or rectangular in section in order to secure a maximum weight with a minimum length. An opening of 12 inches in the side of the pocket is sufficient for hanging the largest unit. These units are manufactured in standard sizes to meet the general conditions found in the building trades.

426. LEAD SASH-WEIGHTS. It often happens that for wide and low windows the weights if of iron would be so long that they would touch the bottom of the pocket before the bottom sash was fully raised. In such cases lead weights are usually resorted to, lead being 80 per cent heavier than cast iron. By casting the weights square, whether of iron or lead, a considerable saving can be made in the lengths.

Fig. 700*b*. The Sanborn Sectional Sash-Weight.

One sash-weight manufacturer † makes a specialty of compressed lead sash-weights, with wrought and malleable-iron fastenings centered so that the weight will hang perfectly plumb; and when lead weights are necessary the architect will do well to specify the weights made by this company. These weights are made under hydraulic pressure, by which greater smoothness, solidity and density of metal is secured than is possible by the casting-process. A wrought-iron rod is run through the center, to which are securely attached the malleable-iron fittings.

In hanging the sashes the weights for the upper sash should be

* Manufactured by the Lidgerwood Manufacturing Company, New York City.

† Raymond Lead Company, Chicago, Ill.

about ½ a pound heavier than the sash, and for the lower sash ½ a pound lighter. Fig. 700, types *c* * and *d* * shows compressed-lead weights.

427. SASH-BALANCES. Within a comparatively few years several devices have been patented for balancing sashes by means of springs instead of weights, but the author believes that only one type, known as the "sash-balance," has proved a practical success. The sash-balance consists of a drum on which the ribbon is wound, and which contains a coiled-steel clock-spring, immersed in oil; the spring sustains the weight of the sash. The common type very much resembles in outward appearance the ordinary sash-pulley, and is applied in practically the same way; the ribbon, which is made usually of aluminum-bronze, is attached to the sashes in the same manner as cord when weights are used.

While the sash-balance in its best form works very satisfactorily, it will probably never entirely supplant the weight and axle-pulley for ordinary windows. There are many windows, however, for which sufficient pocket-room for weights cannot be obtained without spoiling the effect desired or narrowing the glass, as in the bay window, Fig. 209, or where it is undesirable to break the frame into the brick jamb. In such cases the sash-balance is almost invaluable. For hanging the glass doors of show-cases, sash-balances are usually preferable to weights. Sash-balances are made in both side and top-patterns, but the former are recommended wherever there is room at the side of the frame for the depth of mortise required. For windows of the sizes usually found in residences, the depth of the sash-balance measured from the face of the pulley-stile will vary from 3 to 4 inches; this can be provided for usually by cutting a hole, if necessary, in the masonry or studding back of the frame.

As sash-balances require only a plank frame, the consequent reduction in the cost of the frame offsets the extra cost of the balance. In remodeling old buildings which have plank frames without weights, sash-balances will be found a great convenience, since they can easily be inserted in the old frames.

An advantage which all spring-balances possess is that they act most strongly when the sash is down, and so enable one to raise a binding window more readily than if it were hung with weights; while when the sash is up the springs barely suffice to hold it in position and do not offer resistance to drawing it down. Of the various sash-balances on the market, the "Pullman" † and "Caldwell" ‡ are the most extensively used, and undoubtedly reliable.

* Raymond Lead Company, Chicago, Ill.

† Manufactured by the Pullman Manufacturing Company, Rochester, N. Y.

‡ Manufactured by the Caldwell Manufacturing Company, Rochester, N. Y.

The "Pullman Unit" * sash-balance has been on the market many years and has proved satisfactory. These balances are now made with uniform-size face-plates for the various weights of sash with which they are to be used, and thus make it possible to have all mortises for the balances cut at the mill, as is now done for the regular cord-pulleys. The "Caldwell" † sash-balance, both top and side-types, is much used by the United States Post Office and Navy Departments. It is used also by the leading car-builders. The springs are made of high-grade cold-rolled tempered-steel wire, a material similar to that used for clock-springs. The manufacturers guarantee these sash-balances for from ten to fifteen years. Fig. 701 † shows the application of both the side and top-type of the "Caldwell" sash-balance.

Fig. 701. Detail Showing Application of Caldwell Sash-Balance.

428. SASH-FASTS AND SASH-LOCKS. There is such a great variety of sash-fasts in the market that it will be possible to mention but a few. Sash-fasts consist of two plates secured one to each meeting-rail and provided with a bar, catch or cam that locks the two plates, and consequently the two sash, together.

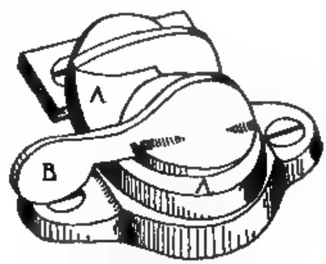
The requirements of a good sash-fast are that it shall be burglar-proof, draw the sashes tightly together in order to prevent rattling, be easy to operate, and be neat in appearance. The principal point in regard to the burglar-proof quality of the fast is that it shall be constructed so that when locked the arm cannot be forced back by a knife-blade inserted between the sashes from the outside. The arm or catch should also have sufficient strength to prevent it from being broken readily by prying up the lower sash, although any window can be opened by using sufficient force.

A great change has taken place in the design of the sash-fasts in common use since about the year 1897. Most of the older styles had a spring attached to the arm which forced it either open or shut, but spring-fasts are now comparatively little used. The old-style fasts, also, were not as a rule efficient for drawing the

* Manufactured by the Pullman Manufacturing Company, Rochester, N. Y.
† Manufactured by the Caldwell Manufacturing Company, Rochester, N. Y.

sashes together, while the later styles are made with this object especially in view.

Probably one of the most popular types of sash-fast has been, up to recent years, the "Cam" sash-fast, which consists of two levers fastened to the lower sash and working on the cam-principle. When the upper lever is turned, the lower, or locking-lever, is first thrown out until released from the hook on the upper sash, and then drawn around and in toward the hub until both levers are on a line with the edge of the sash. The upper lever moves through 180 degrees, while the lower lever is moved through only 90 degrees. The fast is very simple in its construction, and there is nothing about



"Crescent," Cast Metal. Wrought Metal.

Fig. 702. Ives Cam Sash-Fasts.

it that can get out of order. One advantage of the "Cam" sash-fast is that there is considerable play, in and out, to the locking-lever, so that if the sashes are at all loose the locking-lever, by the action of the cam, draws them tightly together, and so prevents the sashes from rattling in a storm. The locking-lever cannot be forced back from the outside.

The "Cam" sash-fast was first brought out by The H. B. Ives Company, but there are now several other cam sash-fasts on the market that are made on practically the same principle and in very nearly the same shape; most of these, however, are inferior to the "Ives." * The "Crescent," * sash-fast has largely superseded the "Cam" sash-fast, although the latter is still used to some extent. One important feature of the "Crescent" sash-fast, as shown in Fig. 702,* is in the operation of the "sweep"; it stops against solid metal in the base, and so insures a more serviceable action. For use on metal sash this firm also makes a sash-fast of malleable iron which is approved by the Board of Fire Underwriters. These fasts are made of both cast and wrought metal, in two sizes and several different styles of finish.

* Manufactured by The H. B. Ives Company, New Haven, Conn.

Fig. 703 * shows a form of sash-lock placed on the market in 1896. This fast is neat in appearance, very simple in construction, efficient in operation, and is in almost universal use. It is so designed that it will both raise the upper sash and draw it into the lower one, for the lever engages in the hook-plate on the upper sash even when the sash is dropped ⅜ of an inch. Two flat springs

Fig. 703. Fitch Sash-Lock.

Fig. 704. Fitch Sash-Lock with Mortise Strike-Plate.

within the lever-plate keep the lever either closed or open, although the security of the lock does not depend upon them. The makers of these sash-fasts make them also for use on fire-proof sashes and steel sashes; the former are approved by the underwriters. Practically all the sash-fasts now used are of this type.

Another sash-fast (Fig. 705) † is rather a novelty, and very extensively used. It would appear to be especially desirable for windows that are not likely to be often opened, as it acts to draw the sashes firmly together and at the same time force them against the top and bottom of the frame. It does not seem to be quite as convenient for ordinary purposes as the fasts shown in Figs. 702 and 703. In order to obtain the best results from cam sash-fasts the plates must have careful adjustment on the frame; the screw sash-fast has considerable latitude. Several self-locking sash-fasts have also been patented, but very few of them have become popular. Fig. 704 * shows the "Fitch"

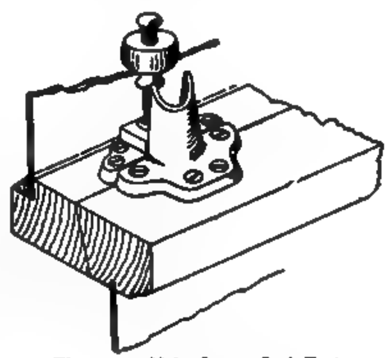


Fig. 705. Yale Screw Sash-Fast.

* Manufactured by The W. & E. T. Fitch Company, New Haven, Conn.
† Manufactured by the Yale & Towne Manufacturing Company, New York City.

sash-lock with motise strike-plate. This is used on window-sashes where the usual-shaped strike cannot be employed.

The simplest device for locking the sashes when partially open is the "sash-bolt" or "ventilating-bolt," Fig. 706, of which several patterns are made in solid bronze. A lug on the inside of the case keeps the bolt drawn when desired; a slight turn of the knob releases the bolt and shoots it into the strike. The bolt is placed on top of the meeting-rail of the lower sash and the strike on the stile of the upper sash. Usually three strikes are placed on the upper sash at intervals of about 2 inches from the meeting-rail, so that either sash may be opened 2 or 4 inches as desired. A regular sash-fast may be used with this bolt if desired, as although the bolt will lock the sashes when closed, it will not prevent their rattling if loose. This device, however, is not used as often now as formerly. A window-ventilating lock * which is applied on the side of the window adds much to the protection given by the sash-fast.

Fig. 706. Ventilating Sash-Bolt.

Fig. 707. Ordinary Hook Sash-Lift.

Fig. 708. Sash-Lift and Lock.

For all first-class work sash-fasts should be of bronze-metal, but a great many iron fasts lacquered or bronze-plated are used. The difference in cost for an ordinary residence, however, hardly warrants the use of the cheaper goods.

429. SASH-LIFTS. These are applied to the bottom rail of the lower sash to afford a hold for the fingers when raising the sash. They should always be specified for plate-glass windows and for all sashes 3 feet wide and over.

Sash-lifts are of four kinds: 1. The flush sash-lift, which is mortised into the rail of the sash so as to be flush, or nearly flush with it. 2. The hook sash-lift, the most common style of which is shown in Fig. 707; it is about the most convenient shape to take hold of, and is the shape most largely used. 3. Bar sash-lifts, which may be obtained either plain or ornamented. For very heavy windows the flush or bar sash-lifts are best, as several fingers can be inserted into the lift. The flush sash-lifts are also neater

* Manufactured by The H. B. Ives Company, New Haven, Conn.

in appearance. 4. Sash-lifts and locks combined. One of the most practical styles of these combined sash-lifts and locks is shown in Fig. 708. The hook is fastened with a pivot and terminates in a second hook, which catches over a plate screwed to the sill. The upper part of the lift is forced out by a spring. Flush lifts with lock-catch may also be had if desired. These locks should be used where there is but one sash to the window, or when the sashes are hung with spring-balances.

Fig. 709 * shows a sash-lift, intended to go on the stile of the sash about half-way up. This is a very convenient sash-lift for the ordinary windows of residences, as it can be used for either raising or lowering the sash; it will be found especially convenient on the upper sash, as well to lower it as to raise it.

430. SASH PULL-PLATES OR SOCKETS. These are

Fig. 709. Sash-Lift Made by Sargent & Co.

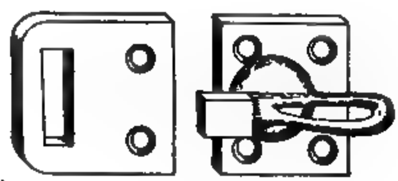


Fig. 710. Turnbuckle for Casement-Windows.

small brass plates with a round hole or socket, which are often screwed to the top of plate-glass windows for pulling down the sash. For this purpose a pole with a hook on the end of it, called a "sash-pull," is used, the hook being made to fit into the socket on the sash.

The use of sash-pulls and sockets prevents the sash from being racked and strained, and they are also a great convenience. They should be of solid bronze on all but the very cheapest work.

431. SASH-STOP-ADJUSTERS. It is becoming the custom in good buildings to secure the stop-beads of the windows, and also of sliding doors, with screws passing through an elongated hole in a round plate or socket let into the stop. The elongated hole or slot is placed at right-angles to the sashes so that the stop can readily be moved in or out as the sashes swell or shrink. They may be obtained in all finishes with screws to match, and cost from 12½ to 25 cents a dozen in ordinary finishes.

432. SINGLE-SASH CASEMENT-WINDOW HARD-

* Manufactured by Sargent & Company, New Haven, Conn.

WARE. The sash is often hung with a pair of light, loose-pin bronze-metal, "Stanley" bronze-plated, or japanned butts. The sash may be secured with a common latch or bolt, or by a double-extension bolt. For windows not more than 3 feet high and opening in, a simple casement-latch or "turnbuckle," like that shown in Fig. 710, will generally prove satisfactory; the strike is so arranged as to force the sash tightly against the rebate, and so short a sash is not likely to spring very much.

When the sash is over 4 feet high, however, a double- extension bolt or an "espagniolette" bolt (see Art. 433) should be used, for if the sash is secured only in the center it will be likely to spring badly at the top and bottom. The mortise double-extension bolt, shown in Fig. 711, makes a very neat finish and a very strong fastening.

A combined mortise extension-bolt and turnbuckle * is made which may be operated by a "lever-handle" or "T handle" or "thumb-knob." The top, center and lower bolts are all "shot" at the same time and the center bolt is dead-locked. The lower bolt-head is made with a spring-attachment so that the bolt will operate should the hole in the strike-plate be partly filled with dirt.

The "Cremorne" bolt, shown in Fig. 664 (see Art. 404), is really a rim double-extension bolt, operated on the same principle. It makes a very handsome trimming for casement-windows opening in or out. Casement-windows may also be fitted with a mortise-lock and latch with lever-handle, special narrow locks being made for the purpose. (See, also, Art. 146, Chapter III.)

433. DOUBLE-SASH CASEMENT OR FRENCH-WINDOW HARDWARE. These windows usually have the meeting-stiles rebated, so that when the swing-leaf is secured it will also secure the standing leaf. The best fastening for a French window is believed to be the "espagniolette" bolt or bar. (See, also, Art. 432.) This is much used in France, and possesses an advantage over the extension-bolt in that it is so arranged as to draw the sash firmly against the window-frame, and thus make it more secure against the weather. Fig. 712 shows a type of the double-rim espagniolette bar, which not only secures the sashes but locks them together and draws them closely to their place. The operation of the bar is as follows: by turning the T handle the hasp is released from the locking-plate, *P*, on the standing leaf, and by turning the handle back the bar is revolved and the hook is released from the strike at the top and bottom of the door. These bars are made with various modifications by several manufacturers.

A mortise espagniolette bar, working on the same principle is made by various manufacturers. If it is desired to secure the

* Manufactured by Sargent & Company, New Haven, Conn.

standing leaf independently of the other, a flush bolt may be used at the top and bottom, but as it is usually desirable to open both leaves of a French window together, it is more convenient to use

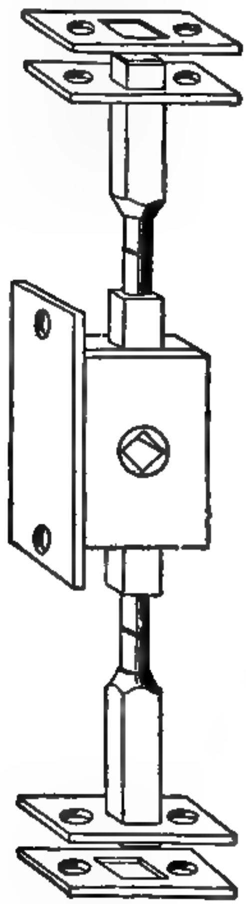


Fig. 712. Double-Rim Espagniolette Bar.

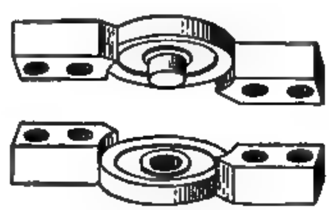


Fig. 711. Double Extension-Bolt.

Fig. 713. Heavy Sash-Center for Vertical Swing.

one double-extension bolt or espagniolette bar. (See, also, Art. 146, Chapter III.)

434. PIVOTED-WINDOW HARDWARE. As stated in Article 147, it is often desirable to pivot windows consisting of a single sash and especially those which are of an irregular shape. For windows of moderate size, pivoted at the sides, the sash-center shown in Fig. 679 may be used. Very heavy or large windows

should be pivoted at the top and bottom, and for such windows the style of sash-center shown in Fig. 713 is preferable. This center is made 4 and 5 inches long, ½ an inch thick, and should be of bronze-metal to avoid rust.

Windows pivoted top and bottom should be provided with a sash-adjuster that will hold the sash in any position. One pattern of

Fig. 714. Sash-Adjuster.

such an adjuster, the "Yale," * is shown in Fig. 714. Sash-adjusters also make the best trimming for a window either pivoted or hung at the sides, unless the window is so high that the adjuster cannot readily be reached, in which case a transom-lifter may be used. If the adjuster is placed with the center of the base-plate 8½ inches from the jamb to which the sash is attached, the sash can be opened 90 degrees, and held firmly at any angle down to 10 degrees. Many forms of adjusters are made by the various manu-

* Manufactured by the Yale & Towne Manufacturing Company, New York City.

facturers. The "Sperry" * is installed entirely beneath the stool with no projections above same, and holds the window in any desired position in a positive and rigid manner. It is operated entirely from within the room. The "Holdfast" † and "Bull-dog" † adjusters work upon somewhat the same principle as the "Sperry," except that the action is partly above the stool in the "Holdfast" and entirely so in the "Bull-Dog." Either of the adjusters mentioned offers a solution of the difficulty of operating casements swinging out, without disturbing screen, storm-sash or draperies. They are made of brass or steel and in all finishes, and may be installed in new or old work. The Casement Hardware Company also make "fasteners" for casements swinging out, and a device called the "Outside In" casement-window cleaner, which greatly assists in the operation of cleaning the casements from the inside. The device supports the casement after it has been swung clear of its butts, and permits it to swing entirely around so that both sides may be cleaned easily. Various other firms,‡ also, make several types of adjusters. Fig. 715 shows the "Holdfast" casement-window sash-adjuster, and Fig. 716 shows the "Bull-Dog" type of the same specialty.

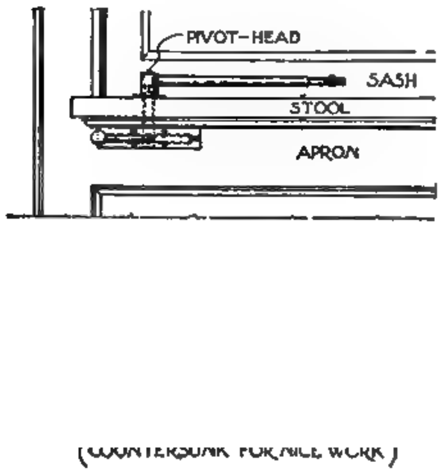


Fig. 715. Holdfast Casement-Adjuster.

An automatic, spring, sash-center is made which the manufacturers ‖ claim will hold any sash in any desired position. The centers are made in different sizes, adapted to the smallest or the largest plate-glass windows and for either vertical or horizontal swing. (See, also, Art. 147, Chapter III.)

435. INSIDE-SHUTTER HARDWARE. The usual trimmings for inside shutters are the hinges, shutter-bar and knob. The

* Manufactured by The Oscar C. Rixon Company, Chicago, Ill.

† Manufactured by The Casement Hardware Company, Chicago, Ill.

‡ The Russell & Erwin Manufacturing Company, New Britain, Conn., and P. & F. Corbin, New Britain, Conn.

‖ Manufactured by The Michigan Engine Valve Company, Detroit, Mich.

outer or hanging fold may be hung with narrow blind-butts, 2 by 1½ inches, similar to the one in Fig. 677, but usually with three screws to a side, and five knuckles. If it is necessary to throw the

Fig. 716. Bull-Dog Casement-Adjuster.

shutters out to clear the finish, "parliament butts," Fig. 717, should be used. These come in widths of 2½, 3, 3½ and 4 inches. For

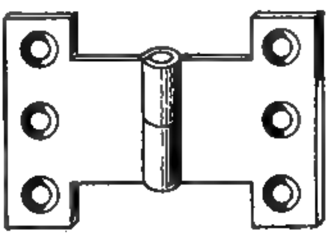


Fig. 717. Parliament Butt.

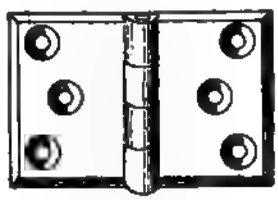


Fig. 718. Surface Shutter-Hinge.

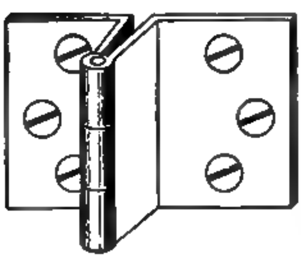


Fig. 719. Three-Fold Shutter-Flap.

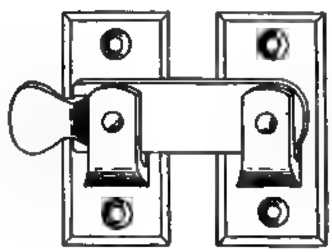


Fig. 720. Shutter-Bar.

hanging the folds to each other, 1¼ or 1½-inch surface-hinges, similar to that shown in Fig. 718, are generally used.

When the shutters are divided into six folds, three to a side, the second fold should be hung with "three-fold shutter-flaps" (Fig. 719), applied to the inside face of the shutters, as shown in Fig. 449.

The usual method of fastening shutters at the center is by shutter-bars of the general pattern shown in Fig. 720. These bars are made reversible so that they can be used for either hand. To pull the shutters from the pocket, a small knob of porcelain or bronze should be placed on the outer face of the hanging fold. Special "shutter-knobs" are made for this purpose, in diameters of ⅞, 1 and 1⅛ inches.

436. OUTSIDE-BLIND HINGES. The kind of hinges to be used with outside blinds will depend to some extent upon how the blind is hung to the window-frame. Throughout many of the western states neither outside blinds nor inside blinds are used.

In New England the blinds are hung generally on the outside of

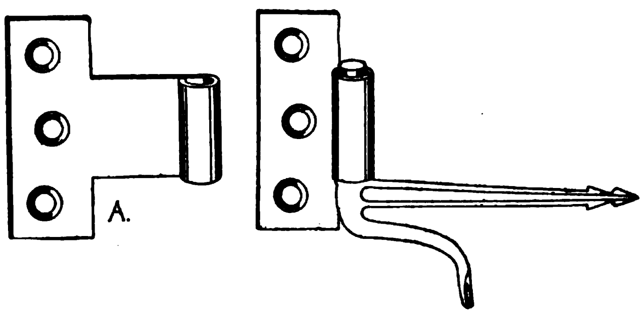


Fig. 721. Wrought-Steel Blind-Hinge.

the casings, and the hinges consist of a half-hinge on the edge of the blind and a hook driven into the face of the casing. Fig. 721 * shows the more common type of such hinges, the position of the parts being that assumed when the blind is thrown open. Two sizes of plates are made, 2 and 2½-inch, the latter affording a more secure attachment.

If there is a molding on the casing, a wider hinge-plate and longer hook must be used to throw the blind beyond the molding; hinges with 2 and 4-inch "throw" are made for this purpose, the hinge-plate being of the shape shown at *A*. The hinge with a 4-inch throw may be used on brick buildings with a 4-inch reveal to the windows. These hinges are very simple and inexpensive, and since they are made of steel will not break.

* Manufactured by The Stanley Works, New Britain, Conn.

Fig. 722 * shows a style of wrought-steel hinge much used in New York City, where blinds usually are set flush with the outside casing. The angle-plate is screwed to the outside face of the blind

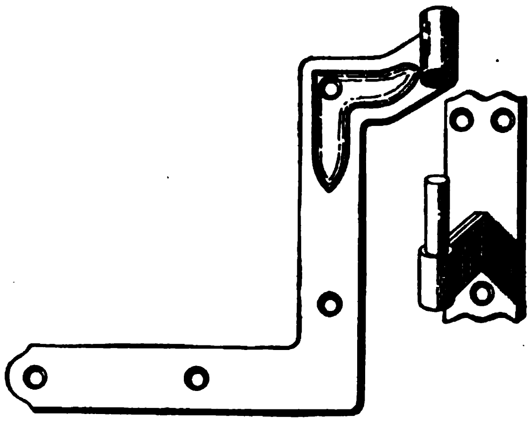


Fig. 722. Wrought Blind-Hinge. New York Style.

and serves to strengthen the latter as well as to give a firm attachment. The bend near the eye is to give a throw to the hinge. A similar hinge with a 4-inch throw is made for windows in brick buildings.

An objection that may be offered to all of these hinges is that the blind swings readily on them in any position, and a catch is required to hold them open and another to secure them when closed. The more recent improvements in blind-hinges, therefore, are in the way of "hold-back" or "gravity"-hinges, as they are called, which lock the blind when it is thrown open, and prevent its slamming. There are several patterns of these gravity-hinges in use, particularly in the western states, and as a rule they have proved very satisfactory. Probably the simplest pattern is that shown in Fig. 723.* It is forged from steel plates and hence is non-breakable

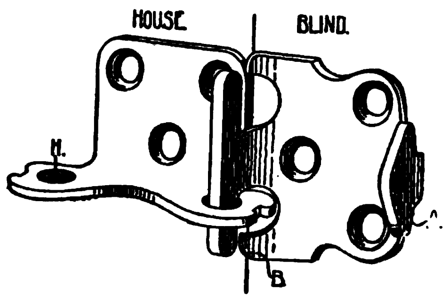


Fig. 723. Stanley Gravity Blind-Hinge.

* Manufactured by The Stanley Works, New Britain, Conn.

and very inexpensive. When the blind is thrown back, the hook *A* engages in the hole *H*, and securely locks the blind. To close the blind it is lifted bodily until the hook clears the hole, when it is readily swung to. The hook *B* prevents the blind from being raised entirely from the hinge, and the two parts can be separated only when the blind is exactly at right-angles with the house. The top and bottom hinges are exactly alike, and can be used either as right or left-hand hinges.

All other gravity-hinges with which the author is acquainted are made of malleable iron. Fig. 724 shows a hinge of this type. One object of its makers was to obtain a hinge that would not project into the window-opening when the blind is thrown back, so that the entire opening between the architrave or casing might be left clear for storm-windows. A good feature of this hinge is that the screw-holes are well back from the edge of the casing.

Fig. 724. "Ideal" Blind-Hinge.

Both of these types of gravity-hinges are made for blinds hung flush with the outside casings or architraves, as in Fig. 155, Chapter III, and throw the blind only about ¾ of an inch away from the house. Several forms of malleable-iron gravity blind-hinges, designed for brick buildings, are used in the western states. Of the latter the "Clark" * and the "Shepard" * give, perhaps, as good satisfaction as any. This firm makes several types of blind-hinges for use with wood or masonry.

437. OUTSIDE-BLIND AWNING-HINGES. Two or three types of blind-hinges have been patented which permit the blinds to be thrown out at the bottom like an awning, as well as to open and close in the ordinary way. One type, the "automatic blind-awning fixture," has been very extremely used about Boston, and seldom fails to give satisfaction. The fixtures are sold with side-bars to hold the bottom of the blind away from the building, and also with a device for fastening the blinds together. It permits the blinds to be used either way, and is very simple in operation.

438. OUTSIDE-BLIND FASTS. When gravity-hinges are used, the only fastening required is a catch to secure the blind

* Manufactured by The Wrightsville Hardware Company, Wrightsville, Pa.

when closed. Fig. 725 shows the catch sold with the hinge, Fig. 723, which, although very simple, works well. The catch is screwed to the inside of the bottom rail of the blind; when the blind

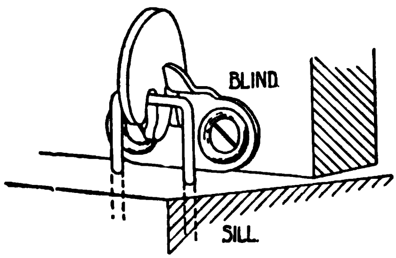


Fig. 725. Catch for Gravity Blind-Hinge.

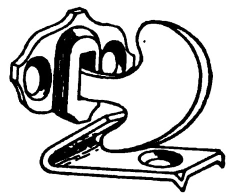


Fig. 726. Stanley Improved Blind-Catch.

is closed, the plate *A*, Fig. 723, catches automatically over a staple driven into the sill. Fig. 726 shows an improved catch made by the same firm.* It works on the same principle but cannot be as easily opened from the outside. There are several other catches very similar to these.

For blinds hung with hinges similar to those shown in Figs. 721 and 722, it is necessary to use a catch that will secure the blind either when open or when closed. Most of the catches for securing

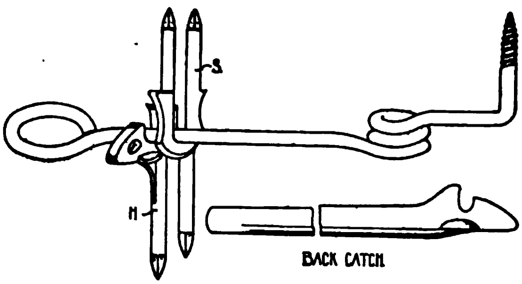


Fig. 727. Stanley Wire Blind-Fast.

the blind in both positions are made to go underneath the blind; there are a great many patterns, but as a rule, the simplest catch is the most satisfactory. The catch shown in Fig. 727 * is very much used in New England, and gives general satisfaction. The end of the wire is screwed into the bottom of the blind, and the staple, *S*, is also driven into the blind. The hook, *H*, is driven into the window-sill and engages the fast when the blind is closed. The back

* Manufactured by The Stanley Works, New Britain, Conn.

catch is driven into the wall to engage the fast when the blind is thrown back.

Underneath catches can, of course, be used only when there is a space of at least ⅝ of an inch between the blind and the sill. If the blind fits into a rebate in the sill, as in Fig. 155, a mortise blind-fast, or one made to screw through the blind, must be used.

To close a blind hung with the ordinary gravity or hold-back-hinge, or with a simple hinge and back-catch, it is necessary to reach far out of the window to raise the blind bodily or to release the catch. To overcome this difficulty, several devices have been patented which operate either from the hanging-stile of the blind or from the sill, and are intended to secure the blind whether open or shut; others adjust the blind to any position and hold it there, while still others are designed to operate the blinds without opening the window. Very few of the devices of the first and second class appear to be used to any extent, but a practical device that will open or close the blind and lock it securely without opening the window, is certainly a very desirable equipment for residences. Several devices that accomplish this purpose have been patented, but the author knows of none that has proved a practical success. Fig. 728* shows a type of shutter-worker operated from the inside.

Fig. 728. Russell & Erwin Shutter-Worker.

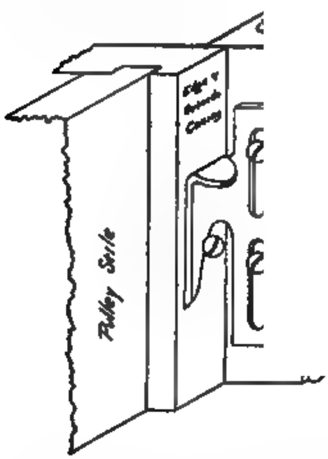


Fig. 729. Moore Storm-Sash Fastener.

439. STORM-SASH HARDWARE. In many of the northernmost states it is a general custom to place a single storm-sash or outside window over the whole window-opening to keep out the cold during the winter months. In many cases the storm-sash, in the autumn, is firmly secured to the window-frames by screws, and in the spring is taken down again. The use of screws, however, involves consid-

* Manufactured by The Russell & Erwin Manufacturing Company, New Britain, Conn.

erable labor and leaves unsightly holes in the outside casings. It is desirable, therefore, that some fastening be used that will allow the sash to be put up quickly and easily, and that will not have a bad appearance when on the house.

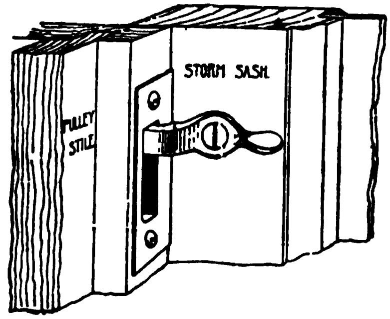


Fig. 730. Willer Storm-Sash Fastener.

The simplest fastening that the author has seen is the one shown in Fig. 729,* which is fastened to the inside of the storm-sash; the hook slips over the shank of a round-headed, blued screw placed in the edge of the outside casing or blind-stop. The wedge-shape of the hook enables the storm-sash to be brought tight against the casing, and also facilitates putting up and removing the sash. Two of these fastenings should be used on each side of the sash.

Fig. 730 shows another simple device for fastening storm-sashes or outside screens. The "button" is screwed to the inside face of the storm-sash, and when turned the outer end fits into a mortise in the edge of the casing, which is covered with a brass plate. The plate has a spring-lap bent into the mortise, which keeps the button in position. The window may be hung at one side with loose-joint butts, which should have a short thick pin, fitting rather loosely; one of these buttons should be used on the other side, or two buttons may be used on each side. The buttons are made in cast iron, copper-finish with brass plate, and in bronze-metal with brass plate, the bronze being preferable. Where outside screens covering the entire window are used, this button may be used on both screen and storm-sash, as the buttons are adjusted to the same pocket-plates.

"Schroeder's" * and "Moore's" * are two types of wrought-steel hangers and fasteners for storm-sashes or window-screens. Several forms of these hangers and fasteners are made in japanned or "Stanley Sherardized" * anti-rust finishes. With these hangers storm-sashes or window-screens can be quickly and easily put up or taken down without the use of ladder or tools. The fastener, which somewhat resembles a casement-window adjuster, operates either from the jamb or sill and permits the sash to be swung out for cleaning or ventilation. (See, also, Art. 142, Chapter III.)

440. CUPBOARD-DOOR HARDWARE. The small cup-

* Manufactured by The Stanley Works, New Britain, Conn.

board-doors of pantries are usually trimmed with narrow fast-joint butts of the pattern shown in Figs. 677 and 678. In the cheaper residences iron butts, lacquered, are commonly used, but brass or bronze, or bronze-plated butts are much neater.

Two general styles of fastenings are used, namely, the "cupboard-catch" and the "cupboard-turn." The principal difference between them is that in the "catch" the latch is drawn back by sliding the knob, while the latch of the "turn" is drawn back by turning the

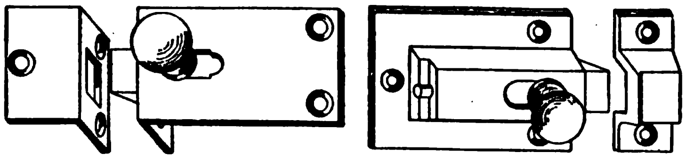


Fig. 731. Flush Cupboard-Catch. Rim Cupboard-Catch.

knob. Cupboard-catches are made both "flush" and "rim," as in Fig. 731, but the "turn," shown in Fig. 732, is made only in the rim-pattern. Several ornamental cupboard-turns especially suitable for the glass doors of the china-closet, may be found in the market. One make * of catches and turns is made with both the common latch and an anti-friction latch. Where cupboard-doors are used in pairs, the standing leaf is secured usually by an elbow-catch (Fig. 733) placed on the back of the door, with a strike fastened to a shelf or to the top of the cupboard.

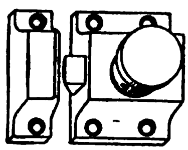


Fig. 732. Cupboard Turn.

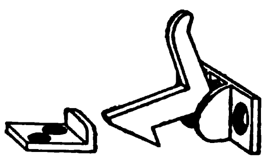


Fig. 733. Elbow-Catch.

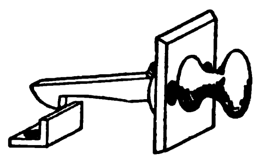


Fig. 734. Lever-Catch.

Fig. 734 shows a lever cupboard-catch that works rather better than the surface-catch, where there is a shelf about opposite the middle of the door.

441. DRAWER-PULLS. These are made in a variety of shapes and sizes, the more common shape, perhaps, being that shown in Fig. 735. Fig. 736 shows a type of pull with a plate for a label, that is known as a "druggist's drawer-pull." The drawers of cabinets and furniture are commonly trimmed with "drop-drawer-

* Manufactured by The Russell & Erwin Manufacturing Company, New Britain, Conn.

pulls," which consist of a drop-handle attached to a plate that is bolted to the front of the drawer. They are made in a variety of patterns and usually in brass or bronze-metal. The common

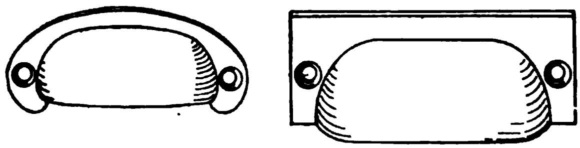


Fig. 735. Drawer-Pulls.

drawer-pull is sold more largely in cast or wrought iron, lacquered or bronze-plated, although it may be obtained in solid bronze.

442. CLOTHES-HOOKS. For clothes-hooks there is nothing better than the triple cast-iron clothes-hook, japanned finish, except the same-shaped hook in brass or bronze. A special upright hook is made for hats. It should be remembered that any iron hook on which damp clothes or cloths are hung will rust after a while, hence the hooks in bath-rooms, toilet-rooms, etc., should be of bronze or brass. The japanned finish for iron will resist rust longer than the other finishes except the Bower-Barff. Hall-stand hooks in cast iron and cast bronze are made by several hardware-manufacturers.

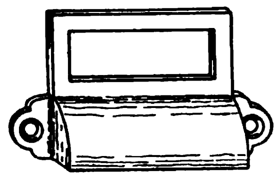


Fig. 736. Druggist's Drawer-Pull.

443. PRICES OF FINISHED HARDWARE. Unfortunately the cost of finished hardware, like nearly everything else that goes into a building, must generally be considered by the architect in preparing his specifications. It should be remembered, however, that the cheapest hardware is not, as a rule, the most economical, and very seldom gives satisfaction. Extra finishes, of course, are merely for ornament, but the difference between cast iron and bronze, or between cast iron and steel, is not one of appearance and expense only, but of toughness and durability, and often means a difference in the wear and working of the article. Trimmings of an inferior quality should be avoided as far as possible, and as a matter of fact, the saving between a fairly good article and an inferior one amounts to a very small sum for an ordinary residence.

444. PUTTING ON THE HARDWARE AND SUPERINTENDING THE WORK. The placing of hardware, when applied to woodwork, should always be included in the carpenter's specifications.

Hardware trimmings require some skill and much care in apply-

ing to insure their working properly, or at least as well as their mechanism will permit; and as a rule, the better the hardware the greater the care required in placing it. The first hardware to be applied is usually the sash-pulleys and the cords and weights. The only way in which sashes can be properly balanced is by weighing each sash, and this, although tedious, is necessary for a good job. The next in order are the butts and mortise-locks. The putting on of the butts is apparently a simple matter, but it requires considerable care to place them so that the weight of the door will be borne evenly by each butt (see, also, Art. 348), and the door hang perfectly true. If one butt is set further out than the other, the door will not remain in its position when opened, but will swing either back into the jamb or around against the wall. The mortise for locks should be cut of the exact size for the front, and in such a way that the case will not bind in the door. The usual height for locks is from 2 feet 10 inches to 3 feet from the floor to the center of the hub. Sometimes it is necessary to vary this distance because of the arrangement of the panels in the door.

The other trimmings should not be applied until the woodwork is finished, painted or varnished; if put on before the painters or finishers are through, the exposed parts are quite sure to be daubed with paint or varnish, which cannot usually be removed without injury to the hardware. In putting on the escutcheon-plates, care must be taken to place them so that the spindle and key-holes will be exactly opposite each other; otherwise the spindle and key will bind in the lock. The knobs should be carefully adjusted also, so that they will not slip back and forth through the lock. Swivel-spindles require particular care in adjusting, for if the swivel does not come exactly at the center of the lock, the knobs will not work properly. In putting on the striking-plate for the lock, carpenters sometimes place it either a little too high or a little too low, so that the bolts or latch will not enter the holes provided for them. As the partitions are apt to settle more or less, the striking-plates should be set so that the centers of the holes will be opposite the centers of the bolt and latch, and thus afford a little play for settlement. Sash-fasts are also often carelessly set, so that they will not lock easily, or will not draw the sashes closely together.

All finishing-hardware is now packed with screws finished to match. These screws are often rather small for the work required of them, and their holding-power is often still further diminished by the carpenter driving them in with a hammer. This should not be permitted; every screw should be turned in its full length with a screw-driver, so that the head will fit neatly into the screw-hole.

If the specifications are written according to the second method, described in the next article, the superintendence will consist principally in seeing that the goods furnished are of the kind specified, and that they are properly put on.

To help determine the first point, hardware is usually stamped or marked so that the architect can tell the make at a glance, but a great deal of hardware can only be told, except by experts, by the label on the box in which it is packed. This is especially true of plated goods and of many makes of locks. It is very difficult to distinguish some plated hardware from solid bronze by merely looking at it, or plated cast iron from plated steel. The superintendent should also remember that there are many imitations of the Bower-Barff finish. Plated goods can be distinguished by scratching with a file on the back, but it is not so easy to tell plated cast iron from plated steel. The labels on the boxes, however, will be, usually, a sufficient guide. Many manufacturers of tumbler-locks make several grades which cannot easily be distinguished from each other, except by examining the inside parts, so that for these the maker's name on a lock cannot always be taken as an indication of the quality. Unfortunately most builders do not appreciate the importance of good hardware, and are apt to try to substitute inferior articles.

When the doors are about to be hung, the superintendent should examine the doors, finish and specifications, to see that butts of proper size to enable the door to swing back (see, also, Art. 351), have been specified, and that the butts are of proper size for the weight and thickness of the door. If these points have been overlooked, they should be corrected before the butts are put on, even if a small "extra" is incurred. Finally every door and window should be tried to see that it locks and swings perfectly, and that the sashes are properly balanced.

If the specifications make an allowance for certain pieces of hardware, the selection should be made by the architect or owner, preferably both together, and it is important that the architect shall have a pretty good idea of the actual cost of hardware; otherwise he may be imposed upon.

445. HARDWARE-SPECIFICATIONS. When artistic hardware of a high grade is to be used, especially for large buildings, it is best not to include the hardware trimmings in the general contract, but to buy them direct from the manufacturers or dealers, selecting from samples. In this way the owner gets just what he wishes and with the least bother. In such case the carpenter's specifications should provide for putting on the hardware.

When it is not practicable to separate the hardware trimmings

from the general contract, one of two methods may be used for specifying them.

The first, and the one that has been largely followed by architects, is to specify that the builder shall allow a certain amount of money for the door and window-trimmings, exclusive of the cost of putting on, the architect or owner to have the privilege of selecting and ordering the hardware wherever he may choose, the bill, up to the amount of the allowance, to be paid by the builder. This enables the architect to put off selecting the hardware until the building is nearly ready for it, and gives the owner a chance to select the style of hardware he prefers. The allowance is sometimes made in a lump sum, and sometimes so much per door and window. The only objection to an allowance is that the architect, to be on the safe side, generally makes the allowance a little more than the hardware which he would specify would actually cost the builder, so that the owner usually pays a little more for his hardware by this method than he would by the other. Then, also, some architects think the trouble of selecting the hardware is often greater than that of describing the goods to be used.

The amount of the allowance will, of course, depend upon the class of goods to be used, and the number of the doors and windows. In making up his estimate, the architect must be guided by his experience and judgment. For both plain and ornamental hardware, prices should be obtained from a local dealer.

A form of specification by this method will be found in Chapter VIII. (See, also, Arts. 446 and 447.)

The second method of specifying the hardware, and in the opinion of the author the best method, is to describe exactly what is wanted, and in the case of special styles or patterns to give the number of the piece in the manufacturer's catalogue, with the material and finish properly indicated. Locks should always be specified by name and number, as most manufacturers make several grades. This method requires a little more knowledge of the subject than the other, but except where elaborate trimmings are to be used it generally gives the most satisfaction; and, when the hardware can be specified in sets, troubles one much less than going to a store and picking out his requirements would do. By this method the architect does not have to deal directly with the matter of cost, but has only to write his specifications so as to include all the hardware required and describe it clearly, and then see as the building progresses that it is furnished according to the specifications. A typical specification of this kind is also given in Chapter VIII. (See, also, Arts. 446 and 447.)

446. DIFFERENT METHODS OF SPECIFYING HARD-

WARE.* "Formerly, when hardware involved no element of taste, still less of art, and was purely mechanical, its selection could safely be left to the contractor or builder, and specifications usually covered little more than a mere statement that the necessary hardware should be furnished and should be of good quality. The revolution accomplished in recent years, however, in the designing and making of builders' hardware, which has elevated it to an important place in the field of decorative art, and simultaneously created new and higher mechanical grades, has radically changed the requirements in specifications relating to this subject.

"Unfortunately the scope and significance of this change are as yet not generally realized, and many hardware-specifications are still drawn on the old lines, with the effect that the desired result is not realized. Doubtless this is chiefly due to want of technical information on the subject, and the purpose of what follows, combined with the information contained elsewhere in this volume ["Locks and Hardware"], is to supply that want. *If the information and suggestions herein contained are made use of, the architect will save himself much annoyance and disappointment, the contractor and builder will be enabled to estimate intelligently, and the client or owner will obtain what he desires and what he pays for.*

"The segregation of the 'hardware of ornament' from the 'hardware of construction' has given rise to several distinct methods of specification, which will be explained and discussed below. Each of them presupposes that the 'hardware of construction,' such as nails, screws, sash-pulleys, chains, weights, etc., and also usually sliding-door hangers and rails, are all covered by the general specifications, and that only 'finishing-hardware,' that is, the 'hardware of ornament,' inclusive of locks and fastenings, is covered by the separate hardware-specifications.

"The several plans most commonly followed are as follows:

"*Plan 1. Hardware Reserved.* Under this plan the finishing-hardware is *omitted* from the general specifications, and reserved for selection by the architect or owner, under stipulation that it shall be supplied at the times and in the quantities needed by the contractor, and that the latter shall properly fit and apply it. Where this plan is adopted, *Form 1* [See Art. 447] should be introduced into the general contract.

"*Plan 2. Hardware Specified Definitely.* Under this plan the finishing-hardware is *included* in the general specifications, but on the basis of a careful selection in advance by the architect or owner, and of a description more or less detailed, based on such selection, contained in the general specifications. Where this plan is adopted *Form 2* [See Art. 447] should be intro-

* Articles 446 and 447 are taken from "Locks and Hardware," by permission of the author, Henry R. Towne, President of The Yale & Towne Manufacturing Company, New York City.

duced into the general contract. Such description may be given by any one of the following methods, viz:

"*Method A.* By name of maker and by actual catalogue-number, or other equivalent exact description. See *Schedule A.* [Art. 447.]; or by

"*Method B.* By general description, covering sizes, weights, metals and finishes, but omitting makers' name and list-numbers. See *Schedule B.* [Art. 447.]; or by

"*Method C.* By reference to samples on file with the architect. See *Schedule C.* [Art. 447.]

"By either of these methods all important questions concerning the finishing-hardware are removed from the field of controversy among rival contestants for the business, but without implying any restriction of competition to insure the purchase of the selected goods at the lowest market-price. Each manufacturer has established prices for his products, which are widely known to hardware-dealers, and competition among the latter can safely be relied on to guard against any attempt to charge unfair prices for the goods covered by a specification of this kind.

"Under this plan the architect or his client, or both, make the selection of hardware, deliberately and carefully, as its importance justifies, precisely as all other important details of material and of permanent decoration are necessarily determined in advance; whereas, when the selection of the hardware is deferred it is apt to be left until the last minute, and then is made under pressure and without due opportunity for thorough investigation and study. If the matter is thus settled in advance, the architect is relieved from the annoyance he is otherwise inevitably subjected to from rival dealers or manufacturers, each importuning him for attention, and also from all trouble arising from differences between the views of the contractor and those of the architect as to what constitutes 'standard hardware of approved design,' as is liable to be the case where the hardware is included in the general contract and left to selection or purchase by the contractor. Moreover, in this way both the architect and contractor, as well as the owner, have definite knowledge in advance, of the cost of hardware, and can include this item in the summary of total cost with certainty that it is correct and final.

"This plan has been adopted during recent years by many leading architects, and with steadily increasing favor. The fact that it had its origin with such members of the profession and is now used by them to the exclusion of other plans is the best evidence of its intrinsic merit. Where it is adopted the specifications for hardware should follow the lines suggested in *Form 2* and *Schedules A, B* or *C* [Art. 447], according to which of the *Methods A, B* or *C,* above referred to, is selected.

"*Plan 3. Hardware Covered by Fixed Allowance.* Under this plan, finishing-hardware is *included* in the general specification, as under *Plan 2,* but on a different basis, which consists in specifying a *fixed sum* to be allowed by the contractor for the purchase of the finishing-hardware, the architect or owner reserving the right of selection within this limit, and of exceeding it on condition of paying the excess-cost.

"This plan is distinctly inferior to either of the two preceding, and has little to commend it except where conditions preclude the definite selection

of hardware at the time and under the conditions which are essential to the best result. It may be easier, at the moment, simply to say that so many dollars shall be allowed for hardware than to select or specify it, but sooner or later it must be selected, and the selection will usually be made with greater care and discrimination if done in advance than if done under the pressure which nearly always exists as the work of building approaches completion. Moreover, as much, if not all, of the finishing-hardware usually has to be *made to order,* its quality will be distinctly better if ample time be given in which to produce it, than if it is made in haste because, for any reason, it has not been ordered until nearly or quite the time when it is wanted. Delay in ordering is also liable to result in delay in delivery, and this in turn may interfere with the finishing of cabinet-work and so retard the completion of the entire building. On *all* grounds it is better that the selection of the hardware should be made at an early date.

"If, however, circumstances compel resort to the method of a 'fixed allowance' its objections will be diminished by the architect or owner making a *preliminary selection* of designs and finishes, and then obtaining from the manufacturer or dealer a preliminary estimate, based on a schedule of quantities compiled from the architect's plans, which estimate, while not final, will at least approximately indicate the allowance which reasonably should be made for the finishing-hardware. While the kinds and quantities of hardware finally selected may not conform exactly to this preliminary estimate, the latter constitutes a safer basis for the 'fixed allowance' than any sum arrived at by arbitrary determination or guess-work.

"Where this plan is adopted *Form 3* [see Art. 447] may be followed in framing the specification for hardware.

"*Plan 4. Hardware Covered by Allowance Per Opening.* Under this plan, commonly known as the 'Boston plan,' as under *Plan 3,* the finishing-hardware is *included* in the general specification, but on a basis which consists in specifying a fixed sum *per opening* to be allowed by the contractor for the purchase of finishing-hardware, and in leaving *to the contractor* the selection of hardware within the limits of price thus indicated.

"Where used *in the above form* this plan is the crudest and most unsatisfactory of any in use. Formerly it was much in vogue in Boston, but fortunately it is now decreasing in use there and is nearly obsolete elsewhere. By leaving the selection of finishing-hardware to the contractor it opens the door to endless controversies, and rarely produces results which are satisfactory either to the architect or his client. In principle it is as illogical as to specify a price at which the contractor is to furnish the completed building, leaving all details of its construction and finish to his decision. The plan is unfair to the contractor as well as to the owner, and is so unsuitable for its purpose that *no suggestion is offered as to the form of specification required where it is adopted.*

"Where, however, under this plan the *right of selection* is reserved to the architect or owner, within the limit of a stated cost per opening, this plan becomes equivalent to *Plan 3,* with the allowance for hardware stated 'by opening' instead or 'in lump.' In most cases it is better to state the allowance in lump rather than by opening, as in this way greater flexibility is

afforded for the exercise of taste or judgment by the architect or owner in the selection of the finishing-hardware when finally made."

In Art. 447, immediately following, will be found "Forms of Specifications" suitable for use under each of the "Plans" above described.

447. FORMS OF SPECIFICATIONS.* The preceding article contains the several methods of specifying hardware which are most commonly employed. The "Standard Forms for Specifications" given below are framed in harmony with the statements contained in the foregoing discussion of this subject, and cover each of the several Plans therein described.

"Form 1. For Use Where Plan 1 is Adopted. Hardware Reserved. The Rough Hardware, such as nails, screws, sash-pulleys, sash-chains (or sash-cord), sash-weights, anchors, screw-bolts, sliding-door hangers, etc., shall be furnished by the *contractor,* and at his own cost, as specified in connection with the carpenters' work or otherwise; all of which shall be of standard quality approved by the architect.

"The Finishing-Hardware, including butts, locks and their trim, and other fastenings and metalwork for doors, windows, closets and cabinets, will be furnished by the *owner,* delivered at the building in the quantities and at the times reasonably needed by the contractor; the contractor to be responsible therefor after delivery and until completion of the building. All finishing-hardware is to be properly fitted and applied in place by the contractor, under the direction and to the satisfaction of the architect. Door-knobs after being fitted in place, are to be kept covered with cloth until the building is completed, to protect them from injury by handling, and all keys are to be cared for by the contractor until the building is completed and then to be delivered to the owner, either in their locks or with tags attached to indicate where they belong.

"The contractor shall furnish the manufacturer or dealer from whom the finishing-hardware is purchased with all information as to the details of woodwork which may be necessary or desirable to enable the party furnishing the finishing-hardware to understand the requirements and to harmonize the hardware with the cabinet-work to such extent as may be necessary and feasible, and, where interferences are discovered, to have them adjusted before the hardware is applied.

"Form 2. For Use Where Plan 2 is Adopted. Hardware Specified Definitely. The Rough Hardware, such as nails, screws, sash-pulleys, sash-chains (or sash-cord), sash-weights, anchors, screw-bolts, sliding-door hangers, etc., shall be furnished by the *contractor,* and at his own cost; as specified in connection with the carpenters' work or otherwise; all of which shall be of standard quality approved by the architect.

"The Finishing-Hardware, including locks and their trim, butts, door-bolts, window and shutter-fastenings, catches, hooks, etc., including therewith knobs, escutcheon-plates and other metal trim for doors, windows, closets and cabinet-work, together with all necessary screws therefor, shall

* Articles 446 and 447 are taken from "Locks and Hardware," by permission of the author, Henry R. Towne, President of The Yale & Towne Manufacturing Company, New York City.

also be furnished by the *contractor* (for the woodwork?) in conformity with *Schedule A* (or *B;* or *C*) attached to and forming part of this specification, in which is set forth the *character* of the finishing-hardware to be used in the several parts of the building. The *quantities* of such hardware required will be ascertained by the contractor from the plans and specifications, and shall be such as to provide the proper fastenings and trim for all doors, windows, closets and cabinet-work, in conformity with the intent of the plans and specifications.

"The contractor shall take charge of, and be responsible for, such hardware when and as delivered at the building by the manufacturer or dealer by whom supplied. At the proper time the contractor, in a suitable and workmanlike manner, shall fit and apply the hardware in place, to the satisfaction of the architect and subject to his approval, being responsible for its proper care and protection until the building is completed and is accepted by the owner.

"The contractor shall furnish the manufacturer or dealer, from whom the finishing-hardware is purchased, with all information as to the details of woodwork which may be necessary or desirable to enable the party furnishing the finishing-hardware to understand the requirements and to harmonize the hardware with the cabinet-work to such extent as may be necessary and feasible, or, where interferences are discovered, to have them adjusted before the hardware is made.

"The decision of the architect concerning any and all disputes arising under this contract relating to the finishing-hardware, or its application, shall be final and binding upon the contractor.

"Schedule A. For use with Form 2. The finishing-hardware required in the building shall conform absolutely, as to maker, catalogue-number, design, size, metal, finish and quality, to the following specifications. (*Then should follow a full and accurate description of the hardware selected, which may be specified by rooms, by opening, by 'combination,' or in such other way as will best meet the conditions in each case.* [An example of this type of hardware-specification will be found in Chapter VIII, under "Hardware-Specifications."]

"Schedule B. For use with Form 2. The finishing-hardware required in the building shall conform absolutely as to size, metal, finish and quality, and as to design where indicated, to the following specifications. (*Then should follow a full and accurate description of the hardware, by items, 'combinations' or rooms, the important details of each article being so fully specified as to secure the desired kind and quality and to exclude inferior and cheaper substitutes. A few examples are given below.*)

"Designs. These shall be subject to selection or approval by the architect from among the stock patterns of manufacturers; those for the hardware for entrance-doors and main floors to be of the best grade, and those for the upper floors of medium grades. The hardware for all service-parts of house to be of plain steel, bronze-plated.

"Metals and Finishes. The hardware for all main parts of the house to be of solid cast bronze or brass, gold-plated for parlor and library, silver-

plated for dining-room, and elsewhere the natural color, polished. In the service-parts to be bronze-metal, polished.

"*Butts.* All butts for entrance, room-doors and closet-doors, except when otherwise specified, shall be of solid bronze (or brass), of the loose-pin five-knuckle type, with ball tips, self-lubricating double steel bushings and 'hold-fast' pins, and of such thickness that a pair of butts of each size shall weigh not less than as follows, other sizes to weigh proportionately, viz:

4 ×4	-inch butts,	2 lbs. 6 oz.	per pair, without screws.
4½×4½	" "	3 lbs. 2 oz.	" " " "
5 ×5	" "	4 lbs. 3 oz.	" " " ".
6 ×6	" "	6 lbs. 6 oz.	" " " "

"Each door or leaf using these butts shall have three butts for doors over 7 feet in height, and two butts for doors 7 feet or less in height. The metal and finish of the butts shall correspond with the hardware of the room in which the knuckles of the butts are exposed.

"*Bolts.* Door-bolts where needed shall have a 'lever-action,' shall be of length to afford an easy reach, and shall conform in metal and finish to the other hardware.

"*Locks.* The locks for all entrance-doors shall be of the cylinder-type, with night-work, ⅝-inch swivel-spindles and not less than 6 inches in height. Those for doors on main floor shall be not less than 4¼ inches in height, with two bolts, not less than three lever-tumblers, solid-steel keys, and 'standard' easy-spring action. Those for bedroom doors shall be not less than 5 inches in height, with three bolts, not less than three lever-tumblers, solid-steel keys, and 'standard' easy-spring action. Those for all service-portions of the house shall be not less than 3½ inches in height with three lever-tumblers and solid-steel keys. Those for storeroom and wine-cellar shall be mortise cylinder night-latches. (*And so on until all varieties of locks required are specified.*)

"*Knobs.* Where bronze (or brass) knobs are called for they shall be of solid metal, the top in one piece, without joint, and shall be provided with a device of established repute, approved by the architect, for attaching them securely to the spindle without resort to any screw-holes in the latter. The knob-shank and its thimble shall be of the 'bracket-bearing' type, that is, with a turned bearing supporting the knob close to its head.

"*Escutcheon-Plates.* These shall be not less than 10 inches long for entrance-doors, 9 inches for doors on main floor, 8 inches for bedroom and closet-doors, and 6 inches for doors in service-portion. They shall be of heavy cast metal, with bracket-bearings for knobs, and shall match other hardware in design, metal and finish.

"*Sash-Fasts.* These shall be of burglar-proof construction and shall operate effectively to draw the two sashes together and to force them vertically against the top and bottom of window-frame. They shall be of heavy construction and shall match the other hardware in metal and finish.

"*Sash-Lifts.* These shall be of the flush type in all main portions of the house, with cup not less than 2½ inches long, and, in the service-portions, of the hook-type, not less than 1¼ inches wide.

"*Transom-Rods.* These shall be of 5/16-inch size in main portions of

house and ¼-inch in service-portion. They shall have an automatic grip, and shall be of length to bring the grip within 5 feet of the floor. They shall correspond in metal and finish with the other hardware of room in which used.

"*Door-Checks.* These, where called for, shall be of the liquid-type, of real brònze, polished, in main portions of house, and of iron, gold-bronzed, in service-portions, and of medium or large size, according to conditions.

"*General.* All other hardware required shall be of standard quality and sizes, conforming in metal and finish to the other hardware of room in which used, and subject to selection or approval by the architect.

"*Note.* The foregoing is merely an outline, is suggestive of the manner in which a schedule of this kind should be compiled, but is by no means complete. The proper method of framing such a schedule is to select carefully a *complete line* of hardware, made by one or several manufacturers and of satisfactory kind and quality, and then to write a description of each group of articles which shall cover all of the important features but omit makers' names and numbers.

"*Schedule C. For use with Form 2.* The finishing-hardware required in the building shall conform absolutely as to maker, catalogue-number, design, size, metal, finish and quality, to the samples already selected and now *on file* in the office of the architect, where they may be examined by the contractor, and where he can obtain full information as to the doors, windows, etc., on which each article shown by the samples, is to be used. These samples will remain on file in the architect's office until the completion of the building, and shall constitute the *standard* to which all finishing-hardware used in the building must conform in every respect. Upon the completion of the building, and before its acceptance, the architect will cause an inspection to be made to ascertain if the hardware actually used conforms in all respects to the samples on file, and also if it has been properly applied and is in good condition; the acceptance of the hardware to be conditioned on a satisfactory result of this inspection, and the decision of the architect to be final and binding upon the contractor as to all questions relating to the hardware so furnished.

"The contractor will be furnished with full plans and specifications of the building, and with any additional information needed to enable him to ascertain the quantities of hardware of each kind required under this specification for the complete equipment of the building, and will be responsible for the furnishing of the quantities so required.

"*Note.* This method implies that a complete selection of the hardware be made in advance, and that arrangement be made with a manufacturer or dealer whereby the official set of samples will be supplied to the architect and be properly tagged for convenient use and reference. When so supplied they should be kept together under lock and key until the contract is completed.

"*Form 3. For Use Where Plan 3 is adopted. Hardware Covered by Fixed Allowance. The Rough Hardware.* The same form of specification for this to be used as indicated under *Form 2.*

"*The Finishing-Hardware.* The contractor (for the cabinet-work?) shall reserve the sum of $.... to be expended, under the direction of the architect, for the finishing-hardware, including therein all locks and their trim, butts, door-bolts, window and shutter-fastenings, catches, hooks, etc., and including therewith knobs, escutcheon-plates and other metal trim for doors, windows, closets and cabinet-work, together with all necessary screws therefor, in such quantites as may properly be requred for the complete equipment of the building in accordance with the intent of the plans and specifications, and to the satisfaction of the architect. The contractor shall fit and apply in place all of said finishing-hardware, in a neat and workmanlike manner, to the satisfaction of the architect and subject to his approval, and shall be responsible for its proper care and protection until the building is completed and accepted by the owner.

"All of the finishing-hardware so required shall be selected or approved by the architect, and no such hardware shall be used, save by the consent in writing thereto of the architect, which is not the product of one of the following manufacturers, viz.: A. B. & Co., B. C. & Co., or C. D. & Co.

"The finishing-hardware shall all be of the best kind and quality obtainable within the limit of the allowance above stated, a proportionate deduction from the above contract-price to be made if the actual cost, at fair market-prices of the hardware selected and finally approved by the architect (with 10 per cent added to such cost), does not equal the above stated allowance; the right being hereby specifically reserved to the owner of selecting and using finishing-hardware of better quality or higher cost than herein contemplated upon condition that, in such case, the owner shall pay to the contractor such additional amount as, with the sum stated above, shall equal the actual cost, at fair market-prices, of the finishing-hardware so selected, with 10 per cent added to such cost to cover the contractor's work in applying the hardware The contractor shall furnish the manufacturer or dealer, from whom the finishing-hardware is purchased, with all information as to the details of woodwork which may be necessary or desirable to enable the party furnishing the finishing-hardware to understand the requirements and to harmonize the hardware with the cabinet-work to such extent as may be necessary and feasible, or, where interferences are discovered, to have them adjusted before the hardware is made."

CHAPTER VII.

Heavy Wooden Framing.

I. FLOOR-FRAMING FOR HEAVY NON-FIRE-PROOF BUILDINGS.

448. FLOORS FOR LIGHT AND HEAVY BUILDINGS COMPARED. The manner in which wooden floors for residences should be framed, has been described in Chapter II. The floors in other classes of buildings are often framed and supported in the same way. The floors of stores, warehouses, mills, public buildings, etc., as a rule, require larger timbers, and should be supported by posts and girders rather than by partitions. In this chapter it is the purpose of the author to describe some of the special forms of construction frequently required in buildings other than dwellings, the methods of framing with posts and girders and what may be designated as "heavy framing."

449. BOWLED FLOORS. In modern Protestant churches it is becoming the custom to pitch the floor so that it will be higher at the back of the audience-room than in front of the pulpit. For such floors the pitch should not exceed ½ an inch to the foot, as a greater inclination is unpleasant to walk over. If the seats are arranged in straight rows the floor should be merely an inclined plane but if the seats are set on a circle the floor should be "bowled," so that any line drawn on the floor from the same center that is used in laying out the pews will be level from end to end. Where chairs are used for seating, a bowled floor is not absolutely necessary, but with pews it is quite essential. There are two methods of forming a bowled floor, their adoption depending principally upon the use that is made of the space below.

1. *First Method.* If there is a finished story below the audience-room, for Sunday-school or similar purposes, it is generally necessary to frame the floor for a straight incline and then form the upper or bowled surface by means of furring-strips cut out of planks.

If the girders supporting the incline run the same way as the inclination they should be given the same pitch as the floor, and the joists will then be level from end to end. If the girders run in

the opposite direction then they will be level endwise, and the joists will be on an incline. Whether the joists or girders shall be inclined depends upon the plan of the room, the openings in the walls and the desired spacing of the columns. In arranging the girders it should be remembered that it is better, and generally more economical, to give the longer spans to the joists and to limit the girder-

Fig. 737. Plan of Bowled Floor, Second Method.

spans to 12 or 13 feet for wood and 16 feet for steel. The greatest span that should be allowed for wooden floor-joists in audience-rooms may be found from the tables in the Appendix. Joists 14 inches deep should be not less than 2½ inches thick, as 2-inch joists are apt to fail by buckling, unless bridged every 4 or 5 feet by solid bridging, and such bridging will usually cost more than the extra thickness in the joists. The furring-strips to form the bowled

surface should be 2 inches thick, and may be either run across the top of the joists or spiked on top of them, lengthwise. When the rise exceeds 8 inches, 2 by 6-inch joists may be used for the furring, and these should be supported from the main floor-joists every 3 feet.

2. *Second Method.* If the space beneath the audience-rooms is not finished, or is used only for such purposes that the position of the piers or vertical supports is not of consequence, the cheapest way to frame the floor is to use short lengths of girders and set them tangent to a circle struck from the center used for the seating. By placing the girders at the proper height the joists may be set on top of them in the right position for receiving the flooring, and no furring-strips will be required. Fig. 737 shows a floor that was framed in this way. A little fitting of the joists on the girders is required, but the labor and material required for a floor framed in this way is not more than 20 per cent greater than for a level floor. When the inclination of the bowl is not over ½ an inch to the foot the floor-boards can be laid in straight lines across the room in the usual way, as the boards will spring sufficiently to fit the floor. The ends of the boards will have to be cut, however, where the bowled surface terminates, unless the bowling is very slight.

2. FRAMING OF GALLERIES.

450. GENERAL CONSTRUCTION OF GALLERIES. Gallery-floors in churches and theaters are generally supported by the walls of the building at the outer ends, and by columns and girders at the inner ends. The floor is generally stepped for each row of seats and the front of the gallery usually projects 3 feet or more beyond the face of the girders.

451. THEATER-GALLERIES. STEEL CONSTRUCTION. The proper planning of the galleries in a theater or opera-house is a matter that requires considerable study, but as the author purposes to treat only of the framing, he would refer the reader to Mr. William H. Birkmire's book "The Planning and Construction of American Theatres" * for methods of laying out the inclination of the galleries in such buildings.

In the better class of theaters the construction of the balcony and galleries is usually entirely of steel. The following examples of gallery-construction, taken from Mr. Birkmire's book, will serve to illustrate the usual method of framing. Fig. 738 shows the con-

* Published by John Wiley & Sons, New York City.

struction of the balconies in Abbey's Theater, New York City, Messrs. J. B. McElfatrick & Son, architects.

"For the support of the steppings in this theater there are 8-inch steel channels extending from a line of 12-inch-beam girders between the back columns to the inner-circle lattice girders, and projecting nearly 10 feet beyond the girders. The channels are placed

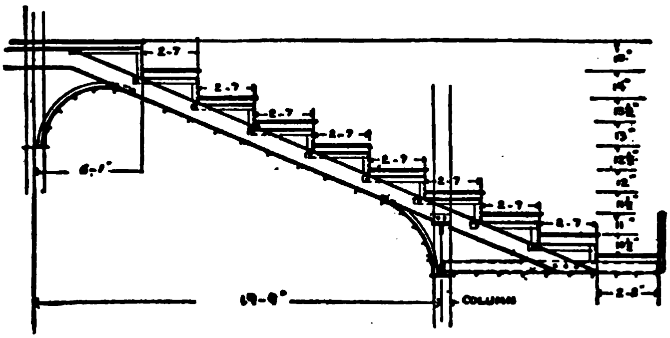


Fig. 738. Gallery-Stepping of Abbey's Theater, New York City.

about 2 feet 6 inches apart and radiate toward the point from which the steppings are described. The steps are constructed of 1-inch yellow-pine flooring upon 2-inch battens secured to stepping-pieces of 1½ by 1½-inch steel angles, bolted to the radiating channels. The risers are made of sheet iron about 1/16 of an inch thick and also secured to the angles. The ceiling beneath is formed by bolting 1¼ by 1¼-inch angles to the under side of the channels every 16 inches, and on these wire lathing is secured. The front of the balcony is constructed of 3-inch channel-posts placed about 4 feet apart and secured to a continuous 6-inch channel extending around the entire front."

In the Empire Theater, designed by the same architects, the steppings are supported by small lattice trusses (Fig. 739) which also radiate to the point from which the steppings are described. Between the trusses, and resting upon the bottom chord, Guastavino arches are constructed, making an excellent and practical fire-proof ceiling, doing away with all furring and making desirable curves for the decorations.

"To support the flooring, which is of 2-inch boarding, knee-pieces of plates and angles are secured to the top chord of each truss, as shown in the illustration. At the top of each knee-piece 2-inch channels, and at the bottom 2-inch angles are secured, extending in a circle the entire length of the galleries. The risers, as in the previous example, are of plate iron."

Another favorite method of constructing these galleries is to use steel beams, placed about 4 feet 6 inches apart, and filled in between with fire-proof arches of brick or hollow tile.

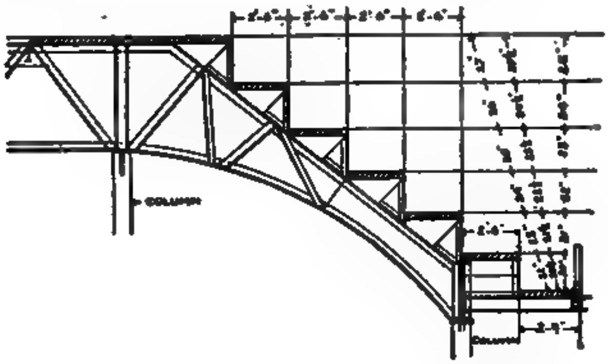


Fig. 739. Gallery-Stepping of Empire Theater, New York City.

"This is no doubt the cheapest form, but the top and bottom of the beams are required to be bent to conform to the girders and steppings of the tiers. If the girders supporting the lower ends of

Fig. 740. Theater-Gallery. Wooden Stepping.

these beams are level the bending is an easy task, but when the front 'rakes' 2 or 3 feet the beams become of different lengths, and

then different bends are required. This construction is also considerably heavier than the Guastavino-arch system and requires more metal in the beams and columns."

Although the width of the steppings is restricted as shown on account of lack of space, it is the opinion of Mr. Birkmire and of others interested in the design of theaters that 2 feet 6 inches is not a sufficient width for comfort.

Fig. 740 * shows a somewhat different detail and more modern construction of theater-gallery wood stepping than that illustrated in the foregoing examples. It is one of the typical methods of construction used at present in fire-proof theaters where wood stepping is employed. The front part of the balcony or gallery is cantilevered as shown, by steel channels and angles and a concrete floor-arch construction is used in between and above the rolled-steel sections. On the concrete of the raking part 2 by 4-inch nailing-strips are set, 16 inches on centers, and to these the 2 by 4-inch stepping-supports are nailed 16 inches on centers. The wood floor-sleepers in the concrete of the level part at the rail are 2 by 4 inches, set 16 inches on centers. All the flooring is 1¼ inches thick and the stepping-risers are covered with ¾-inch-thick flooring. Fig. 741 shows the detail of the framing of the steel channel at the end of the raking cantilever to the gusset-plate and angles.

Fig. 741. Detail of Framing Shown in Fig. 740.

452. CHURCH - GALLERIES. WOODEN CONSTRUCTION. In churches there is usually but one gallery, and as the "sighting" is not as important as in a theater, it is usually possible to regulate the width and height of the gallery, from the main floor, so that a 12-inch step will give the occupants a view of the pulpit-platform and of a portion of the main floor.

Church-galleries also generally have straight fronts, and if pitched lengthwise the inclination is usually the same at the back and front; so that the supports remain the same length. The construction must, as a rule, be of timber, as comparatively few churches can afford steel framing. Every architect, however, should endeavor to have the under side of the galleries protected by wire lathing or some form of metal lathing, as this adds very little to the expense

* This is in accordance with the practice of William H. McElfatrick, Architect, New York, to whom the editor is indebted for this data and drawing.

and would retard for a considerable time the destruction of the gallery by fire. There is also less danger of the plaster dropping from metal lathing than from wooden laths.

When the conditions of the building will permit, the writer has found the method of gallery-supports shown in Figs. 742 and 743 to be the most practical and economical. The support is obtained, according to the span, by 10-inch or 12-inch joists, which rest on girders at the inner end and are built into the walls at the outer end. Especial provision should be made to have the joists well tied to the walls, as otherwise the weight will have a tendency to push them in, or the wall out. At least every other joist should be securely anchored. The wall-end of the joists should also be

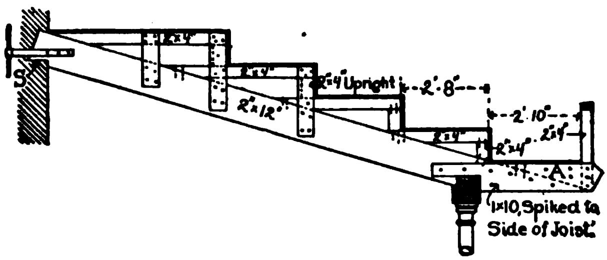


Fig. 742. Church-Gallery Construction.

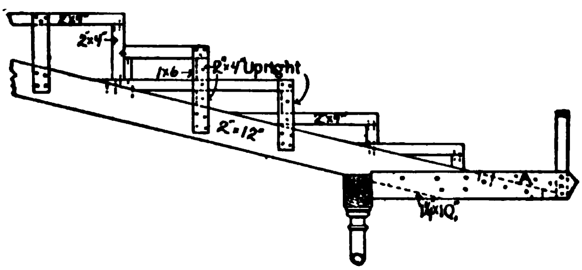


Fig. 743. Church-Gallery Construction.

notched, as shown at *S*, Fig. 742, to give a horizontal bearing on the wall. The steppings may be formed of 2 by 4's, supported by 1¼-inch boards, spiked to each side and to the joists; or 2 by 4-inch uprights may be set under the ends of the horizontal pieces, as shown.

The projecting front, where it does not exceed 3 feet, may be framed by spiking wedge-shaped pieces of planks to the top of the joists, and then nailing wide boards to the sides of both pieces. The rail, if of wood, is generally constructed of a framework of 2 by 4's, ceiled on the inside and paneled and molded as may be

desired on the outside, the top being covered with a wide cap-piece. The uprights of the framework should be securely spiked to the side of the joists supporting the gallery. In churches it is not desirable to have the solid portion of the railing exceed 2 feet in height on the inside, and 22 inches is better. If a higher rail is desired an ornamental rail of 2-inch brass or steel tubing, with

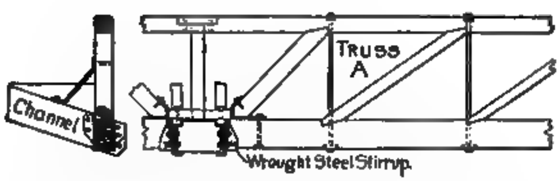


Fig. 744. Framing of Lower Gallery, Mechanics' Hall, Boston, Mass.

standards from 3 to 4 feet apart, may be placed on top of the wooden rail, as this obstructs the view less.

If the projection of the gallery-front beyond the line of the posts is between 3 and 6 feet, the floor may be supported as shown in Fig. 743. In this case it will be necessary to drop the upper ends of the 12-inch joists, so that the inner ends will come about as shown in the figure. In order not to obstruct the view more than is necessary, the depth of the joists under the front step should not exceed 10 inches, the girder should drop as little as possible, consistent with the proper framing for the joists. If the gallery is circular in plan the joists should radiate toward the center from which the steppings are described, and the girder should be built

of two steel channels bent to the proper curve and breaking joint over alternate supports.

453. ASSEMBLY-HALL GALLERIES WITH HEAVY PROJECTIONS. In large assembly-halls it is often desirable

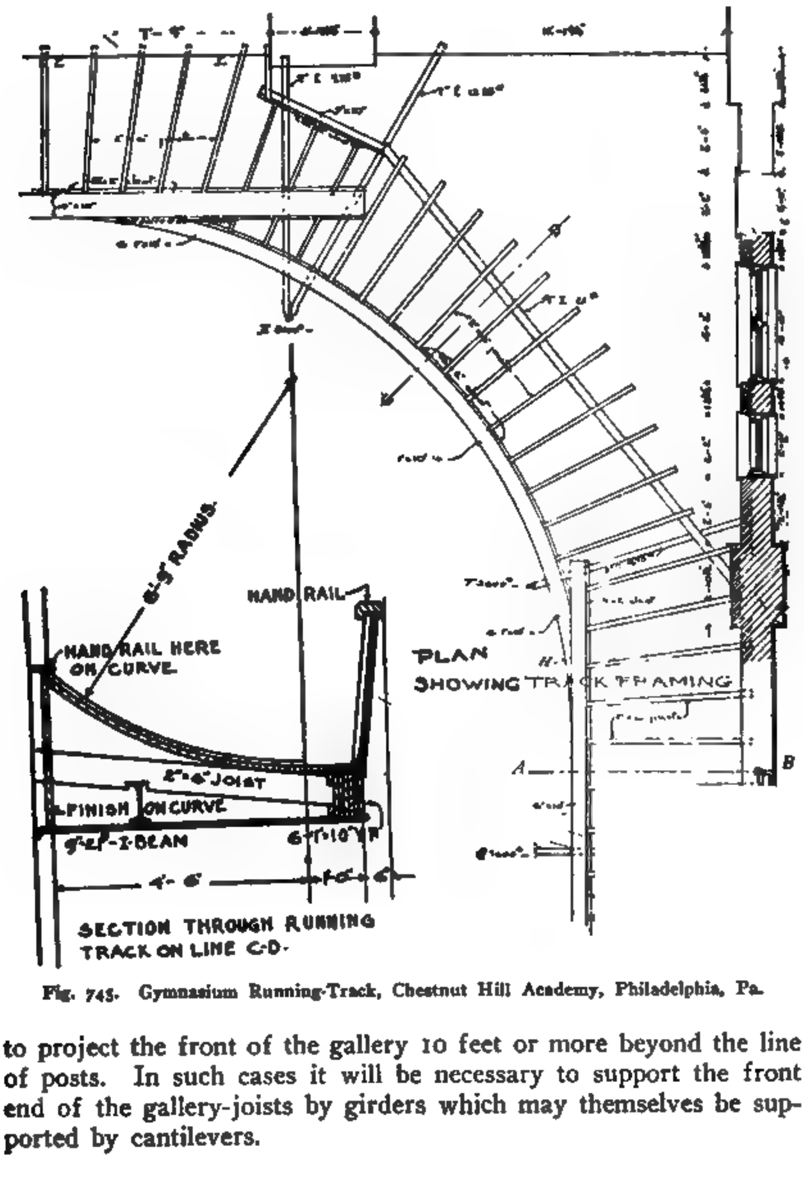


Fig. 745. Gymnasium Running-Track, Chestnut Hill Academy, Philadelphia, Pa.

to project the front of the gallery 10 feet or more beyond the line of posts. In such cases it will be necessary to support the front end of the gallery-joists by girders which may themselves be supported by cantilevers.

Fig. 744 shows, approximately, the framing of the lower gallery in the Mechanics' Hall * in Boston, Mass. The large posts are

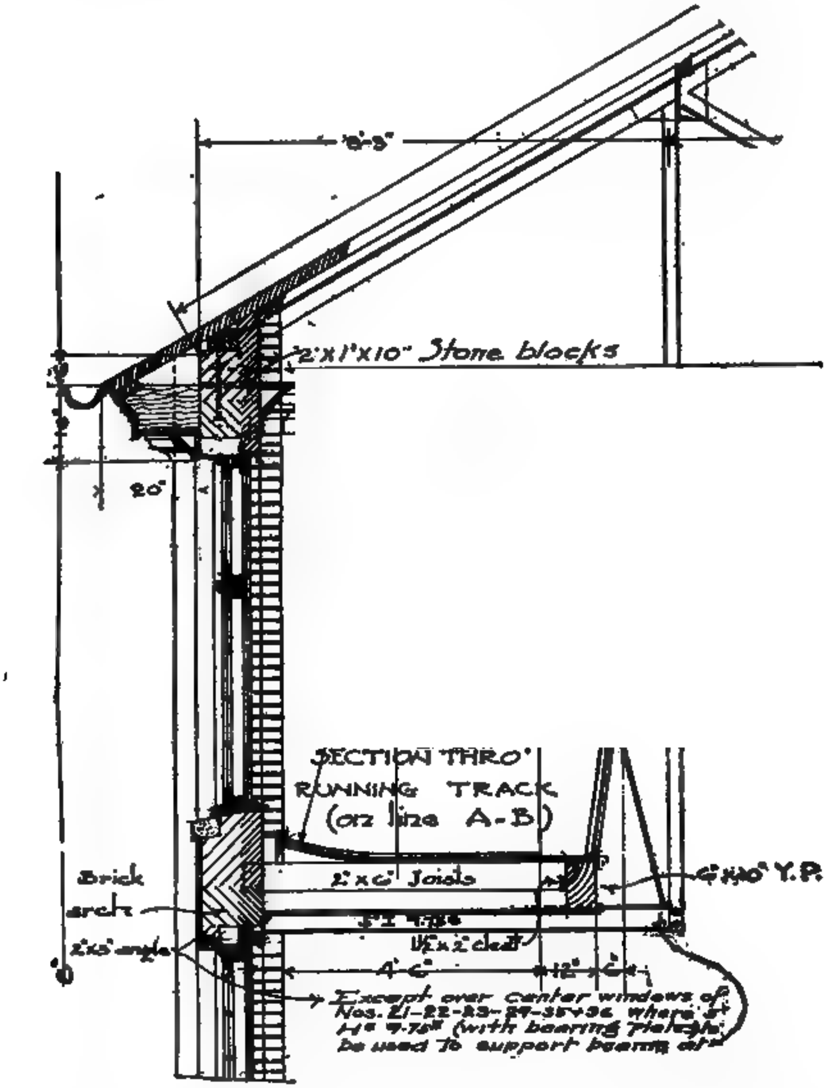


Fig. 746. Gymnasium Running-Track, Chestnut Hill Academy, Philadelphia, Pa.

placed about 25 feet apart and are carried up to support the roof.

* This building was designed by the late Mr. Wm. G. Preston, of the firm of Preston & Kahlmeyer, Architects, Boston, Mass., in 1880 and is still in use (1913). The editor is indebted for data to Mr. James Calderwood, Architect, Boston, Mass., successor to that firm.

trusses. On each side of the posts are placed heavy 12-inch iron channels, in line with the 2 by 12-inch joists, which are bolted to the post, and also supported by the bracket or brace shown in the draw-

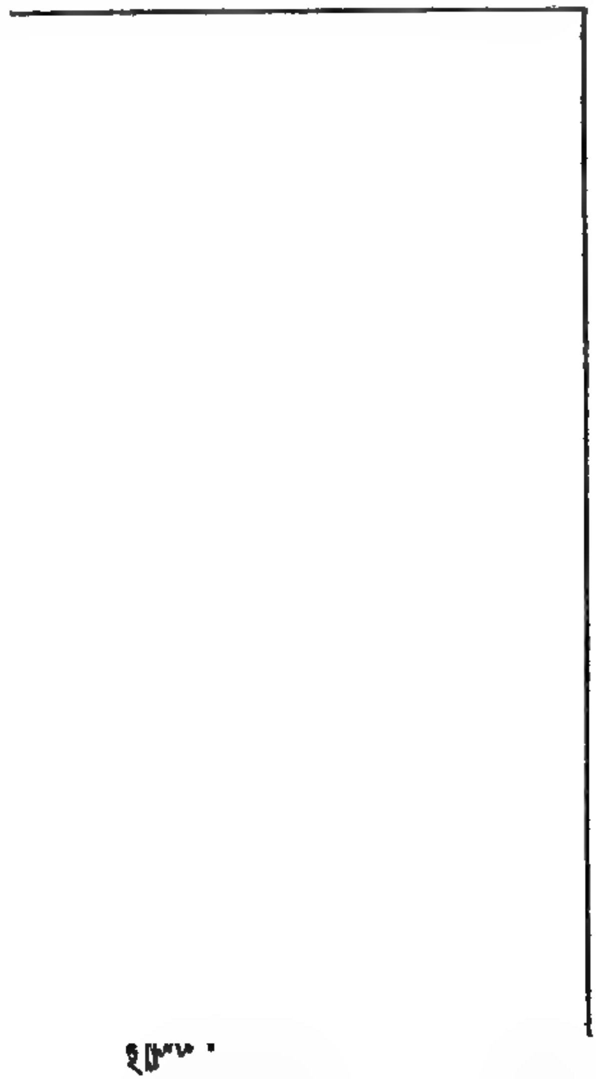


Fig. 747. Gymnasium Running-Track, Designed by the Narragansett Machine Company, Providence, R. I.

ing. The channels thus act as cantilevers, and support at their inner ends horizontal trusses, which in turn support the ends of the

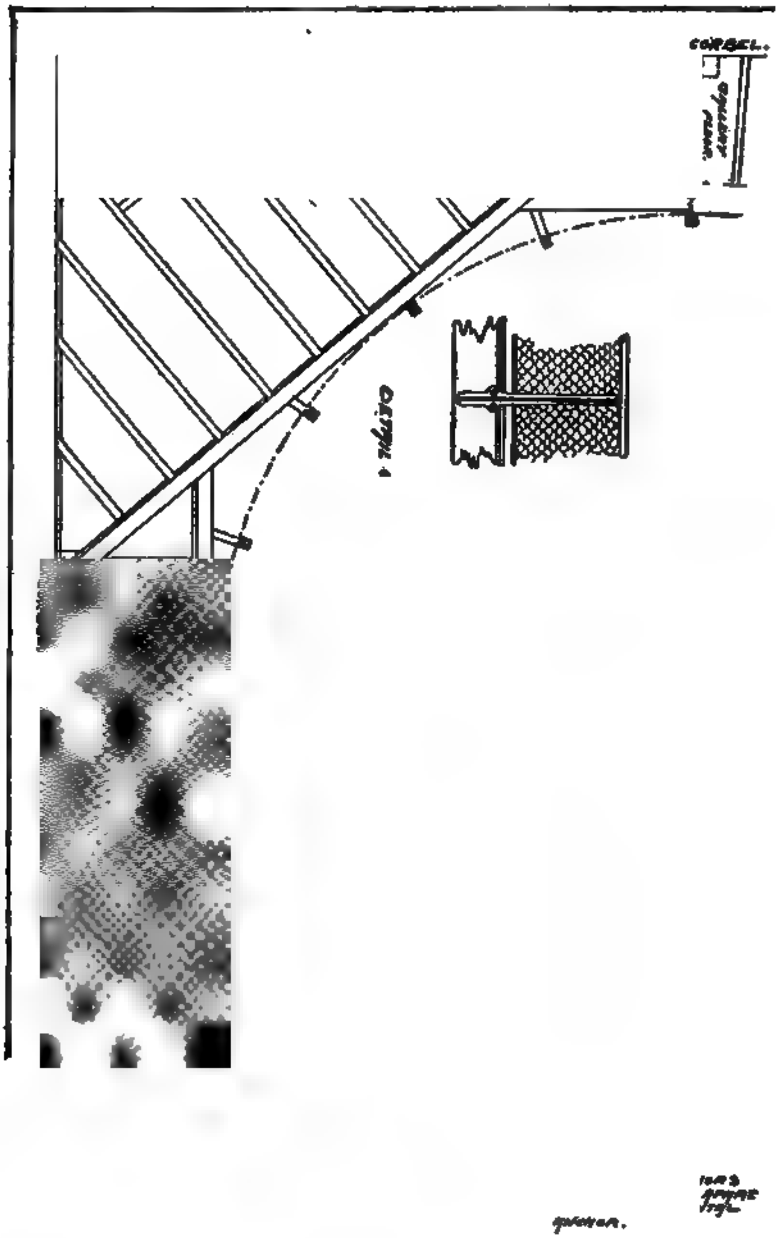


Fig. 748. Gymnasium Running-Track, Designed by the Narragansett Machine Company, Providence, R. I.

gallery-joists. The other end of the joists rest on a partition under the gallery. The middle of the joists is supported by an ornamental open truss extending between the posts. Truss *A*, Fig. 744, is concealed in the gallery-rail. This method of framing is applicable to many places where it is desired to use large posts placed from 20 to 25 feet apart, with a considerable projection to the gallery. Careful calculations of the various stresses must be made, however, to insure safety.

In some cases galleries may be advantageously supported by means of trusses, similar to truss *A*, hung by rods from the roof-trusses. When the depth does not exceed 16 feet the gallery may be supported in this way without posts.

454. GYMNASIUM RUNNING-TRACK GALLERIES. Figs. 745 * and 746 * show a plan and two sections of a portion of the running-track, side walls, cornice, roof and steel truss of the gymnasium of the Chestnut Hill Academy, Wissahickon Heights, Philadelphia, Pa., designed by Frank Miles Day and Brother. The design and details of running-tracks vary in different buildings, but the introduction of one or two types of this kind of gallery-framing may be of interest in this division of the subject of wood construction. Fig. 745 shows a plan of one corner of the track at one of the turns and a cross-section at the curve on the line *C D;* while Fig. 746 shows a section of the track at the straight part on the line *A B,* and of the side walls, windows, cornice, roof and part of one truss of the building.

The track is framed with 2 by 6-inch joists, set 18 inches on centers, the inner ends being built into the brick walls in the straight parts of the track or resting on or notched over I beams, and the outer ends being framed to 6 by 10-inch yellow-pine straight or curved girders. These girders, when curved, are built up of six 1 by 10-inch pieces bolted together. The joists are framed to the wood girders by resting on 1½ by 2-inch wood cleats spiked to girders. At the curve, the inner ends of the joists, for the greater part of the distance, rest on 9-inch I beams the ends of which are either built into the brick piers or rest on steel channels or I beams. The outer ends of the I beams and channels, which run at about right-angles to the general direction of the track, are supported by steel bars of rectangular cross-section, bolted to them and secured to the upper chords of the steel trusses. The inner ends are built into the walls or rest on steel sections over window-openings. The trusses are braced laterally, also. The vertical sections show certain curvatures which, of course, change with every vary-

* Courtesy of Day Brothers and Klauder, Architects, Philadelphia, Pa.

ing radius of the curve according to which each particular track is laid out in plan. These curves shown in a vertical plane cannot, accordingly, be used for any track, having a curve in plan of any other radius. It is the custom of architects to apply to the manufacturers of gymnasium-apparatus for the proper curves in a vertical plane for any particular track-curve radius in plan. The figures in the plan at the sections of the supporting rods from the trusses are the loads in pounds which these rods carry. The handrail is of wood, supported by metal uprights inclined to give more room, and by standing metal braces secured to the outer ends of the track I beams and channels. The under side of the track is finished by ceiling across horizontally with narrow matched ceiling.

Figs. 747 * and 748 * show plans and sections of portions of running-tracks designed by the Narragansett Machine Co., of Providence, R. I. Fig. 747 shows the plan of part of one quadrant of a track with the curved sleepers † and flooring, and the felt and canvas covering of the Roberts running-track.‡ The three sectional drawings of Fig. 747 show a section on the line *A B*, the finish of track against the brick wall and a step-finish which is sometimes required. There is always what is called a "line of inclination," to which the tips of all curved sleepers are set, the track being level for a short width on the inside part. The curved sleepers are set, usually 20 inches on centers, on the rough flooring of the gallery-framing, which is shown in Fig. 748. This latter figure illustrates, also, several sections and detail drawings of the gallery-railing and supports. A common method of wooden-beam floor-framing for the straight runs and corner-turns is indicated in the plan of Fig. 748. The floor-beams vary in size according to span and are set about 20 inches on centers and framed at the inner ends to the 6 by 12-inch wooden girders on the heavier diagonal corner-girders by means of 2 by 3-inch cleats spiked or bolted to same. They are framed at the outer or wall-ends to 2 by 6-inch pieces secured to the walls. Two details of gallery-brackets are shown, one for an iron, and the other for a wooden bracket. In both cases the track-platform is supported, tied and anchored and the variations in the methods are indicated in the drawings. The railing with the inclined support and wire screen is also shown.

In regard to running-track inclines,|| "Everything depends upon the radius

* Courtesy of the Narragansett Machine Co., Providence, R. I.

† The concave track was patented, by W. L. Coop, Oct. 7, 1890.

‡ The Roberts running-track does not form any part of the curved floor or concave, but is laid on the concave track by the Narragansett Machine Co., or such persons as they may permit to use it.

|| Taken by permission from "The Gymnasium Director's Pocket-Book," for 1912, published by the Narragansett Machine Co., Providence, R. I.

of track-corners or ends. If this is too small it is impossible to design an incline that will permit high speeds or even comfortable running at any speed. The following table shows the angle of inclination of the track for a speed of 30 feet per second (100 yards in 10 seconds), the maximum sprinting-speed:

Radius 15 feet; incline 62 Degrees.
Radius 20 feet; incline 55 Degrees.
Radius 25 feet; incline 48 Degrees.
Radius 30 feet; incline 43 Degrees.
Radius 35 feet; incline 39 Degrees.
Radius 40 feet; incline 35 Degrees.

As it has not been found practical to make an incline greater than 45 degrees, this table would indicate that 30 feet is the smallest radius desirable for maximum speed. Athletes are never satisfied with anything short of their best; hence a track to be used by them must be designed for the highest speed. The concave incline should always be designed specially for the radius and speed required."

3. FRAMING OF NON-FIRE-PROOF STORES, WAREHOUSES, ETC.

455. GENERAL CONSTRUCTION OF STORES AND WAREHOUSES. Although the larger stores and warehouses, particularly those in large cities, are now generally built entirely of steel fire-proof or concrete fire-proof construction, the majority of stores and warehouses of ordinary size and many of the larger ones, have an interior wooden construction. The buildings of this latter class built strictly in accordance with mill-construction principles are cheaper than fire-proof buildings and have given excellent service. It has been demonstrated in buildings of this class that when only large-sized timbers are used the building will stand the effects of a fire longer than will a building in which unprotected iron or steel is used. Steel beams used as girders and unprotected will collapse when heated and ruin the building. Or-

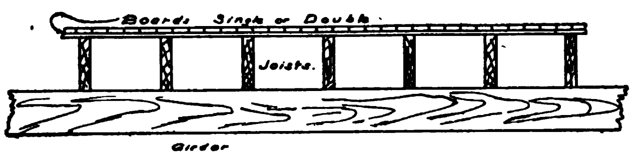


Fig. 749. Common or "Light-Joist" Construction.

dinary construction, sometimes called "light-joist construction," as shown in Fig. 749, is very objectionable as the greatest expanse of wooden surface is exposed. In this class of construction, joists

2 and 3 inches wide are generally used, spaced from 10 to 16 inches on centers and placed on top of the girders. Steel construction, properly fire-proofed, is undoubtedly preferable to wood in many ways, and when it can be employed and at the same time return a fair profit on the investment, the architect should certainly recommend it to the owner. There are many ways, however, in which the ordinary wood construction, as found in smaller cities and country towns, may be greatly improved and made to answer its purposes. Serious objections to the ordinary or light-joists construction are, as above stated, the large surfaces of timber exposed in case of fire, and the pockets and concealed places in which fires are extinguished with difficulty. If, however, the joists are suspended from the girders in hangers instead of being placed on top, the construction is improved, the danger in case of fire is diminished and at the same time a saving effected in the story-heights.

456. PARTITIONS. One of the greatest defects in the ordinary construction of small business blocks, office-buildings, etc., is the supporting of the floors on wooden partitions. No building other than a dwelling should have the floors supported in this way. If the distance between the walls is not more than 24 feet, the floor-joists should be made of sufficient size to span from wall to wall without assistance from the partitions. If the distance between the walls is greater than 25 feet, brick partition-walls, or posts and girders should be used for intermediate supports. For large rooms single spans of 28 feet may be permitted, but this is about the maximum span for which wooden joists can be used with economy.

The principal objections to the use of partitions for supporting the floor-joists in this class of buildings are:

1. Inconvenience in changing partitions. Business-blocks in particular often require alterations in the partitions to suit the convenience of tenants, and when the partitions support the floors they cannot be easily moved.

2. The weight of the joists on the partitions has a tendency to spring the studding and loosen the plastering. The partitions themselves often have insufficient supports, the ordinary 2-inch caps being too thin to support heavy floors. It will generally be found that where floors are supported on partitions the plastering on the latter is badly cracked and the ceiling sags at the center of the partition.

3. Less security in case of fire. Stud-partitions, being constructed of small timbers, are quickly consumed by fire, and but a few moments are required to weaken the studding sufficiently to cause the floors to fall. Girders, on the contrary, being large, solid

timbers, do not burn readily, and will often stand until the fire is extinguished.

457. POSTS, COLUMNS AND GIRDERS IN GENERAL. These should be arranged so that the span of the joists will not exceed 24 feet, 16 feet resulting in greater economy. The girders may be of wood or steel; the former will generally be used except where girders of considerable length are required. With a joist-span of 16 feet it is not good practice to have a greater span than 14 feet for the girders, 12 feet being the maximum span permitted for wooden girders in several cities. The posts or columns may be of wood, cast iron or steel. In buildings of not more than three stories, having wooden floor-beams and girders, iron columns offer no particular advantage over wooden ones, except that they may be made a little smaller in cross-section. Metal columns, unprotected, will not stand as long in a fire as heavy wooden posts. For the comparative advantages of cast-iron and steel columns, and rules for determining their strength, the reader is referred to Kidder's "Architects' and Builders' Pocket-Book."

458. WOODEN POSTS AND GIRDERS. The best timbers for wooden posts and girders are the long-leaf southern yellow pine, Douglas fir and oak. Oak, however, is possibly less desirable, as it seems to be more easily affected by dry rot. During a fire in the Gledhill wall-paper factory in New York City it was discovered that the columns failed under peculiar circumstances. Upon investigation it was found that the oak columns, which had been completely incased at the top by cast-iron post-caps which allowed no ventilation, had been badly affected by dry rot; while some yellow-pine posts in the same building did not show this condition. The posts may be either round or square in cross-section. If round, it is better to leave the upper end square, as it gives a better bearing for the iron cap. The lower part of the post should be round if the post is turned. Posts square in cross-section have a carrying-capacity of one-fourth more than that of cylindrical posts with a diameter equal to the side of the square-section posts. The latter are usually planed and have the corners chamfered. The ends of all posts should be squared off to a true plane, normal to the axis, to prevent flexure due to eccentric loading.

It is generally considered that the durability of a wooden post is increased by boring a hole through its core or axis. This practice is gradually being abandoned by many who seem to attach no particular significance to it. It is recommended, however, by the associations of fire-underwriters.

The New England Mutual Insurance Companies, which insure nearly all of the mills and factories of the New England States,

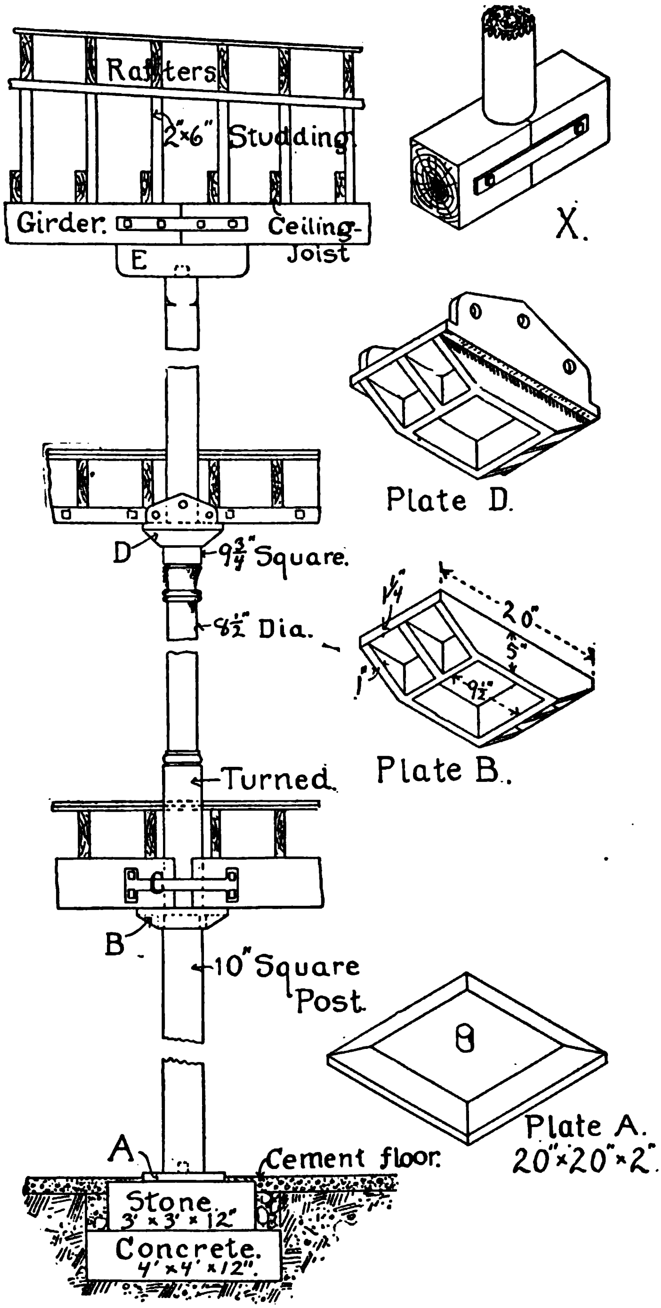


Fig. 750. Tier of Posts and Girders for a Two-Story-and-Basement Building.

advise that a 1½-inch, or preferably a 1-inch hole be bored through the axis of each wooden post, and a ½-inch cross-hole near the top and bottom to give an interior circulation of air. It is claimed that this precaution prevents decay and dry rot, but in ordinary buildings the posts are seldom bored.

The boring should be done entirely from one end, and if the auger comes out more than ¾ of an inch from the center at the other end the post should be rejected. Boring from both ends is often done, but is not recommended, as it is difficult to make the holes meet in the middle.

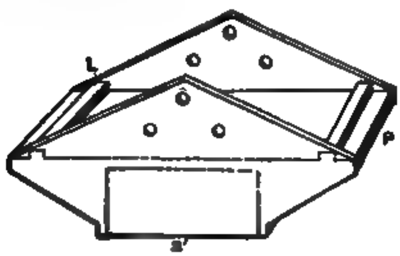


Fig. 751. Goetz Post-Cap.

459. POST-CAPS. All posts should rest on post-caps, and never on girders. The basement-posts should rest on iron plates bedded in Portland cement on brick, stone or concrete piers, the

Fig. 752. Duvinage Post-Cap.

top of the iron plates being kept a little above the concrete floor. (See Fig. 765.) The top of the posts should be fitted with post-caps, which should support the girders and the posts above.

Fig. 750 shows a tier of posts and girders for a two-story-and-basement building.

The same construction is applicable to a five-story building when

the sizes of the columns are properly proportioned. The ends of the girders should be cut to fit closely around the bottom of the

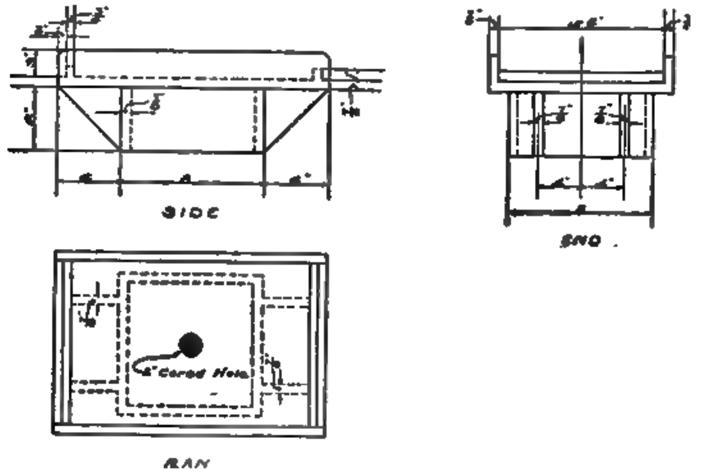


Fig. 753. Common Form of Cast-Iron Post-Cap.

posts, as shown at *X*, if cylindrical columns are used, and tied together longitudinally, either by bolting through the cap, as at *D*,

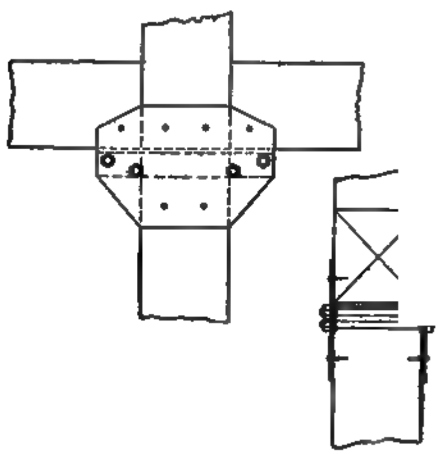


Fig. 754. Two-Way Duplex Steel Post-Cap.

or by iron straps, as at *C* and *X*. The bottom plate, *A*, should have a dowel in the center to keep the post in position until loaded.

The style of post-cap shown at *B* is often used. When the girders and joists are in place, and especially when the building is

occupied, there is no danger of the girders or posts slipping on the plate; in fact it would require a great force to move them and the author doubts if any particular advantage is gained in fastening

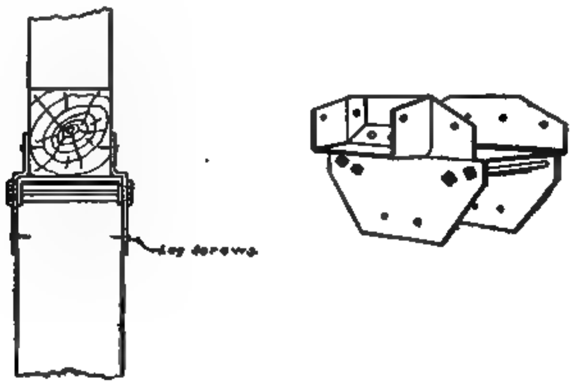


Fig. 755. Duplex Steel Post-Cap for Three or Four-Way Construction.

wooden columns together in a vertical line. If the building should take fire, the posts would certainly be destroyed as soon as the girders, and the bolting of the posts together at the top and bottom would in no way keep them from falling.

Many architects, however, prefer a cap with side-plates like those shown at *D*. The side-plates add somewhat to the strength of the cap and keep the upper post and girder in place while the building is being erected. Holes may be left in the side-plates to secure the ends of the girders and the post above.

Fig. 756. One-Way Duplex Steel Post-Cap.

Figs. 751 and 752 show the "Goetz" and "Duvinage" caps, which are similar to the cap shown at *D*, in Fig. 750. These caps have lugs or dowels cast on the bearing-plate to hold the ends of the beams, and the "Goetz" cap is made so as to be bolted to the posts, the patentee claiming that this will keep the columns upright, even

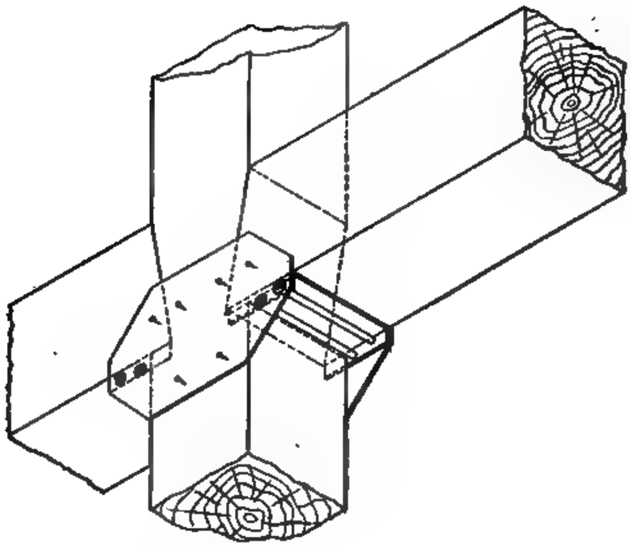


Fig. 757. Duplex Steel Post-Cap for Continuous Post.

Fig. 758. Duplex Malleable-Iron Post-Cap.

Fig. 759. The Star Steel Post-Cap.

if the beams and girders fall. Both of these caps are well-adapted fôr their purpose and are extensively used. Caps similar to *D,* Fig. 750, without the lugs for securing the girders, can be made at any foundry without infringing on the patents.

Fig. 753 shows a common form of post-cap made of cast iron. It is made heavy enough to insure safe construction. But the use of open-hearth steel is rapidly replacing cast iron for post-caps as it is absolutely reliable, makes a perfect post-cap and obviates the uncertainty attached to cast iron. Cast iron is unquestionably a compression-material; but when used in post-caps it is liable to be subjected to tension in the upper portion of the cap when the beam is heavily loaded, causing a non-uniformity of loading and bearing on the cap. The uncertainty due to flaws in the cast iron, or to internal stresses developed from uneven cooling and shrinkage is eliminated when approved, steel post-caps are used. The open-hearth steel post-caps are also preferable to the cast-iron post-caps, as they are stronger, more reliable, lighter and more economical. Another serious objection to cast-iron caps is that in the event of a fire, when a stream of cold water is thrown on them, they break off. If the cap completely encloses the post it prevents ventilation and causes dry rot.

Fig. 754 illustrates a post-cap made of steel and bearing the label of approval and inspection of the National Board of Fire-Underwriters. This cap fits directly on the post and no special work is necessary to apply it. The combination of the side-plates and bearing-bracket bolts, which come just outside of the post, form a complete socket for the post. This cap is made for the different types of framing, namely, the one, two, three or four-way construction, as required, and is easily adapted to "bifurcated," or special framing.

Fig. 755 illustrates the same cap shown in Fig. 754, applied to three or four-way construction and furnished with a bracket riveted to the side-plate which takes care of the beam that frames in at a right-angle. These caps are made for all sizes of posts and girders. Fig. 754 shows the same width of girder as the width of the post below, and Fig. 755 shows how the cap may be adapted to either a larger or smaller girder than the post below. Fig. 756 illustrates a one-way post-cap, and Fig. 757 a steel post-cap for a continuous post. This is used when the post runs through the two stories, or where it is advantageous to use a long post into which a girder or beam frames, and it is not desired to cut the post. The use of this continuous post-cap makes a very strong and economical construction.

Fig. 758 shows a malleable-iron post-cap, consisting of an upper and lower channel, riveted together and adapted to many variations

of girder and post-construction. The advantage of malleable iron over cast iron is appreciated by engineers, and this cap is often given preference over cast-iron caps. The cap shown is patented and bears the label of approval and inspection of the National Board of Fire-Underwriters. The first figure shows a cap for a larger post and smaller girder and the second figure, a cap for

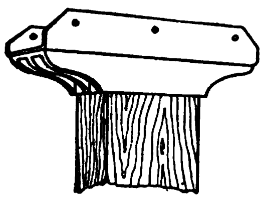


Fig. 760. Duplex "Combination" Post-Cap.

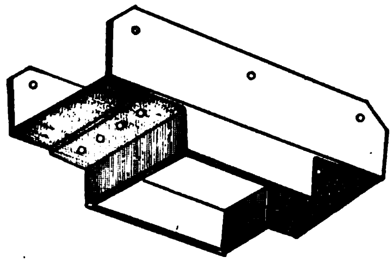


Fig. 761. "Ideal" Steel Post-Cap.

a smaller post and larger girder. Fig. 759 shows another type of steel cap approved by the National Board of Fire-Underwriters. This cap, however, is by some authorities considered objectionable from an engineering standpoint, as the finn is inserted in a slot cut in the top of the post. In the checking and twisting of the post this is liable to split the latter.

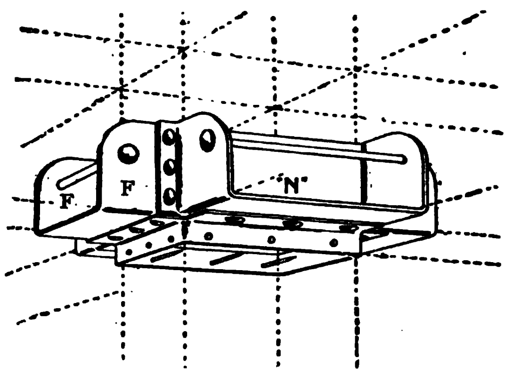


Fig. 762. Van Dorn Steel Post-Cap.

Figs. 760, 761 and 762 show various other types of post-caps, which, while all right for ordinary construction, are not as suitable as some others for the most heavily loaded buildings. Figs. 761, 762 have the label of approval of the National Board of Fire-Underwriters. Fig. 760 shows a cap, the bottom portion of which is made of malleable iron and the top channel of steel. Fig. 761 shows a form of post-cap made entirely of steel, suitable for lighter construction. Fig. 762 shows a double post-cap made entirely of forged steel. The side-flanges, *F, F,* extend the full length of the cap, and the bracket-bearing at *N* is riveted to the side-flange and to the bottom-ring. The post-caps for

a girder in one direction only are made without the bearing *N*.

Figs. 763 and 764 show perspective, side and end-elevations and plan of a steel post-cap for cylindrical columns, iron-pipe columns or concrete-filled columns. (See, also, Art. 462.)

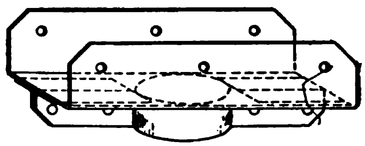


Fig. 763. Steel Post-Cap for Cylindrical, Pipe-Columns.

The upper post may be capped by a wooden bolster, as at *E*. Fig. 750, if preferred. The top of the post should be doweled into the under side of the bolster or secured by two square drift-bolts, and the ends of the bolster should be spiked or bolted to the girder. The bolster should also be made of the hardest wood obtainable, preferably oak, so that the fibers will not be crushed where they bear on the top of the post. If the building has a flat roof, with a ceiling beneath, the ceiling-joists should rest on a girder, the rafters being supported by a short partition of 2 by 6-inch studs, also resting on the girder.

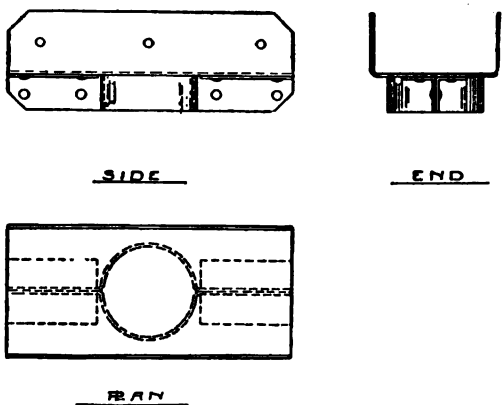


Fig. 764. Steel Post-Cap for Cylindrical, Pipe-Columns. Side, End and Plan.

Fig. 765 shows a post-base made entirely of steel. It can be made for every size of post and with the necessary spread to distribute the load over the masonwork.

The strength of wooden posts may be found from the tables given in Kidder's "Architects' and Builders' Pocket-Book," or from those in the Appendix. Posts eccentrically loaded should have a greater cross-section than if concentrically loaded.

460. BEARING-AREA AND FORMS OF POST-CAPS AND CAP-PLATES. 1. *Method of Determining the Area.* The iron cap-plates should be of such size that the girders will

have a bearing of at least 5 lineal inches at each end, and the edge of the plate should not project more than 6 inches beyond the post, unless absolutely necessary to get a sufficient bearing-area.

The bearing area required for the end of the girder should be found by dividing one-half the load on the girder, if the load is symmetrical, or the proper reaction, if the load is unsymmetrical, by 500 for oak, 350 for long-leaf yellow pine, 200 for Douglas fir and 200 for spruce. If the area thus found, divided by the width of the girder, is less than 5 inches, however, the latter distance should be taken as the minimum lineal support, except for very light girders.

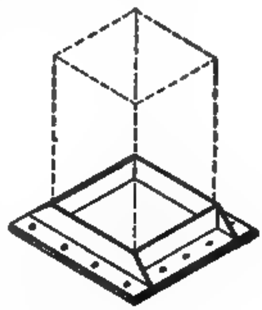


Fig. 765. Steel Base for Wooden Post.

2. *Example of Bearing-Surface for Cap-Plates.* A 10 by 12-inch long-leaf southern yellow-pine girder is calculated to support 20,000 pounds, uniformly distributed. What bearing should it have at the ends?

The solution is as follows: One-half the load would be 10,000 pounds, and this divided by 350 gives about 28 square inches for the bearing-area. Dividing this by 10, the width of the girder, we have 2.8 inches. As this distance is less than 5 inches the latter is

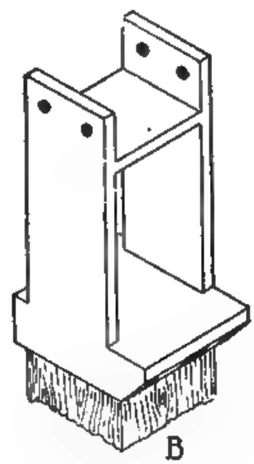
Fig. 766. Cap-Plates for Cylindrical and Square-Topped Posts.

the bearing-distance to be used. If a spruce or Douglas fir girder were used, the distance would be exactly 5 inches by calculation for the 10 by 12-inch size.

3. *Different Forms of Cap-Plates.* Cylindrical posts are generally preferred to square-section posts, as they are less in the way; but there is necessarily a loss of strength in turning, as the sec-

tional area of the post is considerably diminished. For posts turned the whole length, an iron cap like that shown at *A*, Fig. 766, may be used. The cap shown at *B* is often used when the top of the post is left square in section and there is no post above.

Occasionally it is necessary to make the girders continuous over a post, or the post may support the end of a truss, in which case the post above cannot come down to the post below. For such construction a hollow cap-plate should be used, something after the style of cap shown in Fig. 767. The cap should come down at



A.

Fig. 767. Hollow Cap Plate, Side View and Perspective. Continuous-Girder Construction.

least 3½ inches on the lower post, and should be bolted to the upper post.

4. *Proportions for Cap-Plates.* Rules for calculating the size of brackets, etc., for cast-iron bearing-plates are given in Kidder's "Architects' and Builders' Pocket-Book," Chapter XIII. As a general rule the depth of the bracket should not be less than three-fourths of its projection.

The bearing-plate should be 1¼ or 1½ inches thick and the socket-plates ¾ of an inch or 1 inch thick.

The socket which encloses the top of the post should be made ½ an inch smaller than the nominal size of the post, so that it will be sure to fit tightly over it.

In designing iron castings the thickness of all the parts should be nearly uniform, so that they may cool evenly and thus avoid initial stresses.

As steel plates and caps are much stronger than those of cast iron and not subject to internal stresses, the thickness of their metal need not be more than about one-half that of the cast-iron cap.

461. CAST-IRON COLUMNS. Cast-iron columns are superior to wooden posts, in that they do not decay, can be made smaller than wooden posts and are not damaged by wear and tear. They also have an appearance of greater strength and durability, although this appearance may often be deceptive. When not protected by fire-proof materials they are quickly injured by fire and water, and in a fire will stand no longer, if as long, as wooden posts.

The shell of cast-iron columns that carry any weight should not

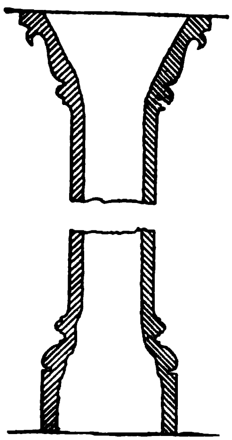


Fig. 768. Section of Cast-Iron Columns. Incorrect Method of Casting.

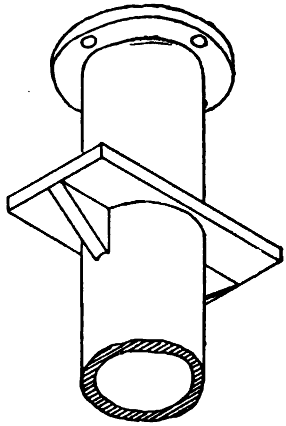


Fig. 769. Detail of Top of Cast-Iron Column for Use with Wooden Girders.

be less than ¾ of an inch thick, and should be cast straight from end to end; and under no circumstances should a supporting column be cast as in Fig. 768. If the column is to be loaded with 60 per cent of its calculated safe load, the thickness of the metal should be tested by boring one or more small holes through the shell and measuring the thickness of the opposite side by means of a stiff wire. A difference in thickness of more than ⅛ of an inch should not be permitted.

The ends of all columns should be turned in a lathe to a true plane at right-angles to the axis. The lower column should rest on a cast-iron plate with a raised cross cast on it to fit into the column. The portion of the plate which receives the column should also be turned. The upper columns should be bolted to those below. Fig. 769 shows the manner of casting the top of the columns

where wooden girders are used. The top of the column should come about 4 inches above the top of the girder, unless the joists are framed flush, to facilitate bolting the columns together.

The ends of the girders should be tied together by straps on each side, as shown in Fig. 750.

If for any reason a very large cap-plate or hollow box is required to support the floor-construction, it may be cast separately and bolted to the top of a plain column, the bearing-surfaces being turned to fit closely.

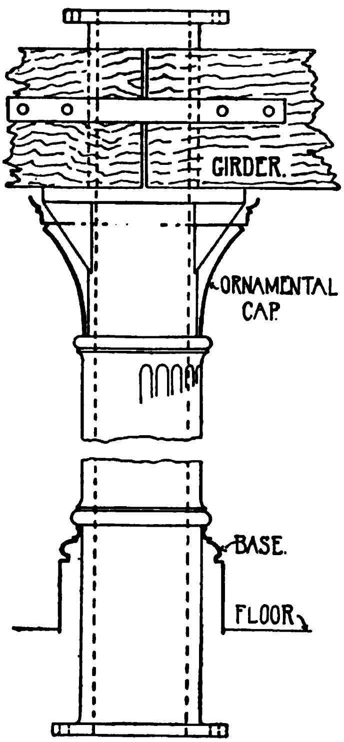


Fig. 770. Detail of Cast-Iron Column with Ornamental Cap and Base.

If an ornamental cap and heavy, projecting base are desired below the girder, they should be cast in separate pieces and screwed to the columns, as in Fig. 770.

462. STEEL-PIPE COLUMNS. A particular demand for steel-pipe columns is at the angles of show-windows in mercantile buildings. In buildings of moderate height the floor-joists are usually supported by the side walls and the columns have to support only a relatively light wall above. For such places wrought-steel pipes may be advantageously used for the columns. They may be used, also, for the columns supporting the roof of one-story buildings. In several cities, however, New York, Brooklyn, Philadelphia, Boston, Chicago and others, pipe-columns are used for interior construction to carry I beams supporting floors, walls, and chimneys in all classes of buildings, such as tenements and apartment-houses, factories, garages, churches, warehouses, etc. In Brooklyn, pipe-columns are calculated according to the formula $S = 14{,}000 - 80\ l/r$, in which S, l and r have values as explained below for the New York City formula. If the columns are filled with concrete, the area of the cross-section of the concrete is multiplied by 500 and the product added to the load supported by the pipe. This formula gives a factor of safety of four. The New York Bureau of Buildings uses the formula $S = 15{,}200 - 58\ l/r$, in

which S is the permissible unit fiber-stress, l the length in inches and r the radius of gyration of the cross-section of the pipe. This gives a carrying-capacity about 10 per cent greater than that of the Brooklyn formula. In Philadelphia pipe-columns are allowed to carry about 25 per cent more than is allowed in Brooklyn. Where pipe-columns are filled with concrete the cast caps and bases are secured to the pipe by concrete which is reinforced internally by a pipe of smaller diameter. Where these steel-pipe columns filled with concrete are used, care should be taken that the pipes are entirely filled, and that there are no air-spaces in the concrete. These concrete-filled columns, sometimes reinforced with smaller pipes, have a large carrying-capacity. Pipe columns may have their supporting-power about doubled in many cases by concrete filling. One type of steel post-cap used in connection with pipe-columns to carry wooden girders is shown in Figs. 763 and 764. There are many other forms of cast and wrought caps for pipe-columns. The design of proper caps and bases is the most difficult part of adapting tubular columns to practical problems in building-construction.

A wrought-steel pipe when used as a column generally has the following advantages:

1. It will support a greater load per square inch of section than any other shapes and styles of mild-steel columns of the same slenderness-ratio, l/r, for most of the columns of different slenderness ratios recently tested (1908 and 1909) at the Watertown Arsenal.

2. Its section has the greatest possible "least radius of gyration," r, for the same outside diameter and area. This makes pipe-columns especially advisable when it is desired to obstruct the view as little as possible, as in the corners of show-windows, in balcony-supports, etc.

3. It may be used with greater slenderness-ratio, l/r, than any other section without reducing the load per square inch in order to conform to permissible loading-rules, such as those of the New York City and Chicago building codes.

4. Its curved walls permit the use of relatively thinner material than may be used with columns with flat surfaces; that is, its thickness, t, divided by the outside diameter, d, may be $t/d = 1/80$ with as great security from wrinkling (called also "buckling," "bulging" or "local failure") as the box column, which good practice of competent engineers limits to 1/50 of the unsupported width of flat surfaces. The ratio $t/d = 1/80 = 1/4''/20''$ is about the limit of practicable working of the ordinary lap-weld process, and all commercial pipes have a smaller ratio.

5. Manufacturers are now regularly making pipe for sizes up to and including 16 inches outside diameter, in lengths up to 40 feet.

The following general notes and suggestions should be observed in the use of steel pipe for columns:

1. As in the case of columns of any construction, it is obvious that competent designing and detailing as well as proper fabrication of the end-connections for pipe-columns be insisted upon. Otherwise the advantages of the circular section may be nullified.

2. When the loading must be eccentric care must be exercised in the proper selection and size of pipe to be used. The relative economy in the use of the circular section, however, increases with the length and slenderness of the column.

3. A capital or base should never be screwed to a pipe, because cutting the thread reduces the section. Where screw-threads must be used, only the area below the root of the threads should be considered as available for the supporting-power.

4. The ends of pipe to be used for columns should always be faced off in a lathe, the facing being normal to the general axis. A pipe should not be turned nor bored in fitting capitals or bases but, if possible, the capital or base should always be forced or shrunk to an even bearing on the faced end of the pipe. Where the capital or base must be inserted, it is liable to start a wrinkle or buckle and the load should be adjusted to the probable lessening of supporting-power. The bearing-surfaces in capitals and bases should be, of course, always lathe-faced. It may be found that with careful foundry-work it is not necessary to bore the castings; but it may, in some cases, be cheaper to use poor foundry-work and bore the castings, as well as face the seats.

5. Pin or ball-and-socket ends are generally preferable to flat or fixed ends for a slenderness-ratio l/r, of 100 or less, because tests show that columns so fitted usually carry higher loads before failure. This is increasingly evident as l/r decreases. Any form of end-connection of column that may cause a flexure from a failing floor may endanger the whole structure.

6. All columns should have sufficient stiffness to safely withstand the chance deflecting forces to which they may be exposed. This usually involves consideration of eccentricity as well as of flexure due to transverse load.

7. It is desirable to adhere always to the trade-sizes of pipe known as "Merchant," "Standard," "Extra Strong," "Double-extra Strong," "Casing," "Boiler-Tubes," etc., and avoid special production which usually entails delays and special prices.

8. Tables XLVII, XLVIII and XLIX in the Appendix show the loads which "Standard," "Extra-Strong" and "Double-Extra-Strong" steel-pipe columns are permitted to carry under the New York building code. The Chicago code permits slightly greater loads. The supplementary table of "Double-Extra Strong" steel-pipe columns may be useful in cases where a minimum diameter is required; but it should be remembered that such pipe always costs more per pound, owing to its greater cost of manufacture.

463. CONNECTIONS OF FLOOR-JOISTS AND GIRDERS. In buildings of ordinary construction, that is, with floor-joists 2 or 3 inches thick, the girder is often dropped so that the floor-joists may rest on top of it, as shown for the first floor, Fig. 750. Very often the joists and girders are framed as shown for

the second floor, a cross-section of the girder being as in Fig. 89. In either case the joists should be tied together across the building by iron dogs (see Fig. 89) once in every 4 feet or by spiking the ends of the joists together. If strength and economy alone are to

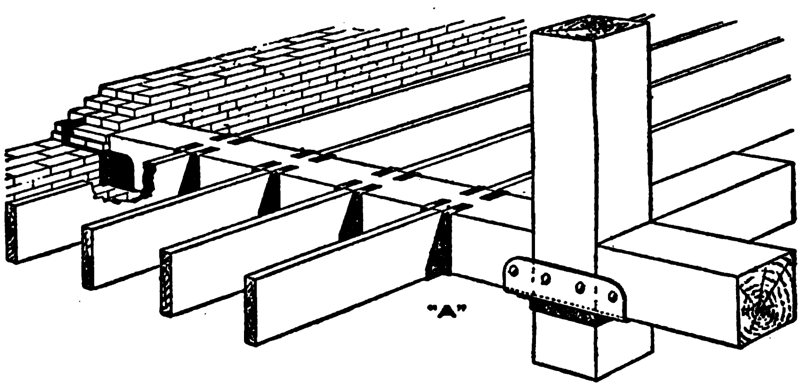


Fig. 771. Van Dorn Joist-Hangers and Post-Cap.

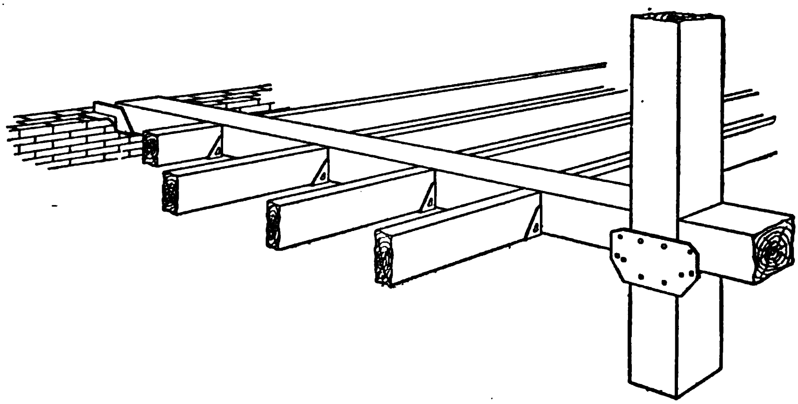


Fig. 772. Mill-Construction Adapted to Stores, Office-Buildings, Etc.

be considered, placing the joists on top of the girder is the most economical method, and as strong as any.

From a slow-burning standpoint, however, this is the worst kind of construction as it leaves a space above the girder around which flames can lap, and also affords a chance for the accumulation of dust and dirt which in the course of time adds inflammable matter for a fire to feed upon. With the joists framed flush with the girder on top, no spaces are left and the girder will be much longer

in taking fire. The flush girder, also, gives a much better appearance to a room of moderate height.

When the beams are framed flush, in all buildings other than dwellings and small private stables, they should be supported either by steel or malleable-iron joist-hangers, or by stirrups. (See, also, Art. 100.)

Figs. 771 and 772 show the ideal methods of framing buildings of ordinary construction, one with the "Van Dorn" and the other with the "Duplex" hangers. If the ceiling is to be plastered it will perhaps be best to use the "Duplex" or "Goetz" types of joist-hangers, as they are not so much affected by shrinkage as are some other forms of hangers. (See, also, Art. 100.)

464. BRACING OF WOODEN POSTS AND GIRDERS IN HEAVY FRAMING. Buildings of several stories having the floors supported by posts and girders without partitions are not very rigid; hence, if a building is very high, so as to be affected by wind-pressure, or if it contains machinery, it is very desirable to brace the posts and girders at the angles formed by their intersection, as shown in Figs. 773 and 775. Such bracing also adds materially to the strength and stiffness of the girders, but not to the posts.

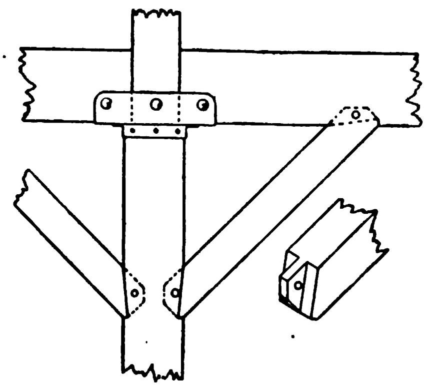


Fig. 773. Bracing of Wooden Post to Wooden Girder.

A very interesting paper by Prof. Edgar Kidwell of the Michigan College of Mines, entitled "Comparative Tests of Bracing for Wooden Bents," was published in Volume IV, of the Proceedings of the Lake Superior Mining Institute. From the tests therein described, Prof. Kidwell found that for wooden braces, the best method of framing the brace to the post and girder, all things considered, is that shown in Fig. 773. Cast-iron knees of the pattern shown in Fig. 774 were found to add little to the stiffness of the bent, until the latter had deflected more than would be admissible in a building.

As a result of his studies and experiments on the bracing of wooden bents, Prof. Kidwell patented the brace shown in Fig. 775. It consists of a piece of ordinary gas-pipe or steam-pipe, fitted by right and left-hand screw-threads into cast-iron shoes, designed to

be secured to the posts and girders as shown. For structures containing very heavy machinery, the shoes should be secured by bolts, preferably passing outside of the post; but for stationary loads, lag-screws may be used. The drawing shows the brace as applied in the top story, or where the girder passes over the post; but it is equally efficient when the girder rests on a post-cap, as in Fig. 773, the ends of the girders, of course, being well tied together.

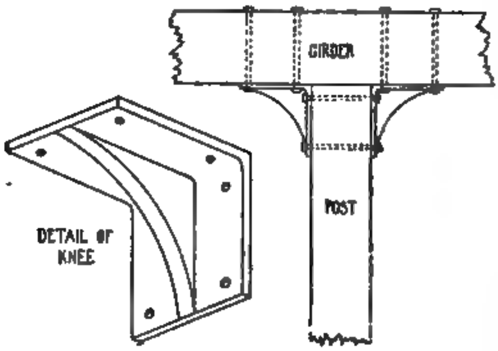


Fig. 774. Knee-Bracing of Wooden Post to Wooden Girder.

The obvious advantages of this brace over the wooden brace are greater rigidity of connection, less weakening of the post and girder and opportunity for adjustment in case of shrinkage in post, or settlement of girder. Other advantages are that the brace can be

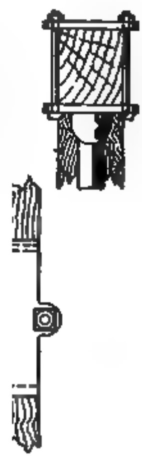


Fig. 775. Metal Braces for Wooden Post and Wooden Girder, Kidwell Patent.

applied at any time to old as well as to new buildings; it is also less clumsy than the wooden brace.

The sizes of pipe to be substituted for various sizes of wooden braces are as follows:

For a 4 by 4-inch brace, a 2½-inch pipe; for a 4 by 6-inch brace, a 3-inch pipe; for a 4 by 8-inch brace, a 4-inch pipe; and for a 6 by 8-inch brace, a 4½-inch pipe.

465. FRAMING FOR AREA-WALLS. Buildings having storerooms in the first story, and rooms or offices above, generally require an area on one or both sides to furnish light and ventilation for the inside rooms. As in such buildings the ground-floor commands the greatest rental per square foot, it is essential to utilize the full area of the lot; and to do this it is necessary to start the light-area at the level of the second floor, the first story being lighted by a skylight, which forms the bottom of the area.

A very common arrangement of such buildings, when erected on

Fig. 776. Partial Second-Story Plan, Showing Light-Area.

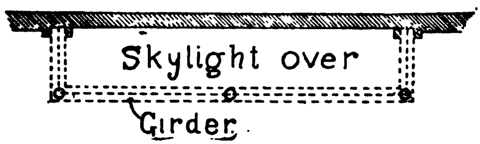


Fig. 777. Partial Plan Showing Cheap Method of Framing for Light-Area.

an inside lot, is shown in Fig. 776, which is a plan of one side of the second floor, the stories above being divided in the same way. For city buildings of the ordinary construction the area and party walls are usually of brick. As the area-walls start from the second-floor level, they must, of course, be supported on girders of some kind. There are two methods of construction commonly employed in framing and supporting these girders. The cheapest method is that shown in Fig. 777. Girders of suitable size are placed directly under the area-walls, and are themselves supported by columns or posts spaced at economical distances, as shown in the figure. Constructionally, this method is probably the best, as it economizes material and carries the loads more directly to the foundation; but the posts are usually considered objectionable in a store, and are apt to decrease the rent. It is, therefore, generally desirable to frame the girders supporting the area-walls so that the columns may be omitted. The method of accomplishing this is shown in Fig. 778,

which represents the framing of a portion of the second floor in a building 50 feet wide.

Girders *A, A, A* are placed crosswise of the building and from 10 to 14 feet apart, the outer ends being supported on the first-story wall and the inner ends on the columns which support the middle tier of girders.

The girders *A, A, A* support the girders *B, B,* which carry the wall above. The latter girders may either be framed between the

Fig. 778. Plan of Area-Framing Without Columns.

Fig. 779. Section of Construction Shown in Fig. 478.

former or may rest on top of them; in the latter case it will be necessary to drop the girders *A, A* below the ceiling-line. It would probably be more economical to frame the girders flush and drop both below the ceiling, as in that case the floor-joists would rest on top of the girder *B, B.* When the latter is flush with the ceiling the joists must be supported by I-beam hangers, I-beam box hangers or I-beam shelf-hangers as described in Chapter II, Art. 100. Keeping the girders *B, B* flush with the ceiling, however, obstructs the light from the skylight much less than when they are dropped. Fig. 779 shows a section through the bottom of the light-area with the girders *B, B* flush with the ceiling, but does not show the I-beam hangers.

In brick buildings over two stories in height the girders *A* and *B* should be steel beams, used in pairs; or, if these cannot be obtained of sufficient size, riveted box girders should be used.

The floor-joists in the third and upper floors, and also the rafters, are supported by the area-wall, hence the load on the girders A and

B is very considerable and must be computed with great care. It must also be remembered that the girders *B, B* transmit a concentrated load to the girders *A*, *A*, and the size of the latter must be computed accordingly.

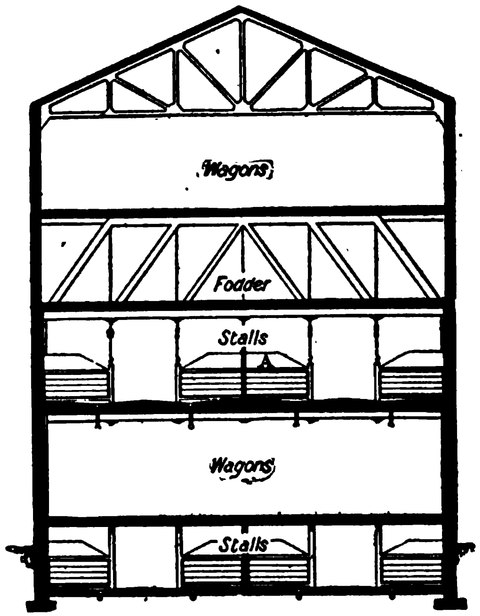


Fig. 780. Section of Stable-Building of the Adams Express Company, New York City.

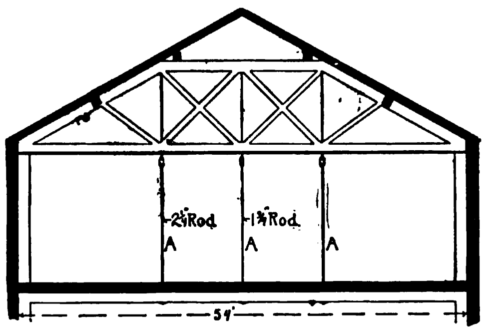


Fig. 781. Section of Upper Story of Museum of Fine Arts, St. Louis, Mo.

The depth of the girders should be such that the deflection does not exceed 1/30 of an inch per foot of span. If either of the girders is dropped beneath the ceiling it should be protected from fire by metal lathing or tile.

The load which the beams *A, A* transmit to the wall should also be carefully computed and a bearing-plate of proper size placed under their wall-ends. It will also probably be necessary to reinforce the wall by pilasters, as shown in Figs. 777 and 778.

If the side wall is a party wall, or comes close to the lot-line, it will be necessary to convey the rain-water through soil-pipes placed inside the building and to provide a gutter at the foot of the sky-light to collect it. Fig. 779 shows the usual method of forming the gutter and finishing the wall.

466. FLOORS SUPPORTED BY RODS AND TRUSSES.*

* See, also, "Building Construction and Superintendence, Part III. Trussed Roofs and Roof Trusses," by F. E. Kidder, for further data on trusses. See, also, Kidder's "Architects' and Builders' Pocket-Book," chapters on Roof-Trusses.

1. *The Construction in General.* In planning large stables and buildings containing assembly-rooms, it is very often necessary to provide in intermediate stories, rooms 40 or 50 feet square, without posts or other vertical supports. If such rooms are not more than 50 feet wide the floor above can be supported by riveted or trussed girders; but as the riveted girders are quite expensive and as either must drop considerably below the ceiling, supporting members of these types are not generally practicable unless the story is a very high one.

The usual method of supporting the upper stories in such buildings is by means of trusses and suspension-rods, as illustrated in Fig. 780,* which represents a section through the American Express Company's stables, designed by Mr. Peter B. Wight, built on East Forty-eighth Street, New York City, and demolished in 1907 to make room for the enlargement of the Grand Central Station and yards.

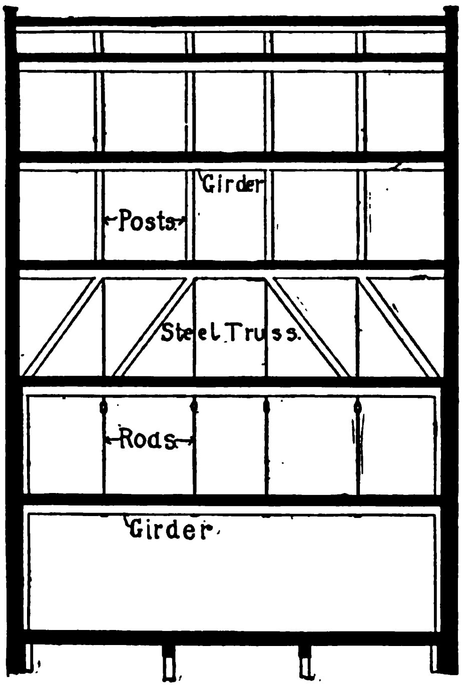


Fig. 782. Section of a Building Showing Floors Supported by Truss.

In these buildings the first and fourth stories were devoted to the storage of wagons, and were entirely free from posts or rods. The floors of the third and fourth stories were supported directly on the bottom and top chords of ordinary Howe trusses, and the floor of the second story hung from the trusses by rods. The roof over the upper story was supported by independent trusses.

The trusses being placed in the story used for the storing of fodder, interfered little with the convenient use of that space. The rods in the story below passed through the stall-posts and were thus entirely out of the way.

If only one floor above the open story is to be supported it may

* Taken by permission from the *Engineering Record*, Vol. 31, No. 1.

be hung directly from the roof-trusses, as shown in Fig. 781, which illustrates the method of supporting the floor over the auditorium in the Museum of Fine Arts,* St. Louis, Mo. In this case the rods *A, A, A* are concealed in partitions. Where the arrangement of the stories will permit, it is undoubtedly better construction to support the second and third floors above the open story by means of Howe trusses, as in Fig. 782, and if there are additional floors above, they may be supported by posts or columns, as shown in the same figure. Placing the truss near the lower part of the building lessens the weight borne by the walls above and also increases the stability of the building, as the truss acts also as a brace to stiffen it against swaying laterally. Where trusses support several stories by means of columns, the latter should always be of steel. When supporting floors by means of trusses it must be remembered that all the weight borne by them must be transferred to the walls, and the higher the truss is placed the more "top-heavy" the building will be and the greater will be the quantity of material required in the piers supporting the trusses.

It is always better, when the purpose of the building will permit, to support the floors on columns running through continuously from foundation to roof; and when an open story must be provided it should be placed as near the top of the building as the conditions will allow. There are numerous buildings, however, in which many stories are supported by trusses in the manner shown in Fig. 782; and many of the tallest buildings have the wall-columns for the entire height of the building supported on cantilever trusses resting on the foundation-piers.

In the Crocker Building,† San Francisco, seven stories are supported by trusses in a manner very similar to that shown in Fig. 782.

The Schiller Building,‡ Chicago, containing the New Garrick Theater, has seven stories supported by steel trusses, the members of which are riveted and fire-proofed, placed just over the theater and carry lines of columns, the ceiling of the theater being double-fireproofed. The construction of this building was, in its day, a somewhat startling procedure but now such details are commonplaces of architectural engineering.

2. *Truss-Rods and Suspending-Rods.* As a rule, not more than one story below the trusses should be hung by rods. The manner of securing the suspending-rod from wood trusses is also a matter

* Designed by Peabody & Stearns, Boston, Mass.

† The interior of this building was gutted by the fire which followed the earthquake of 1906, but the steel frame and outer walls were uninjured and the building was renovated. It was originally designed by Mr. A. Page Brown.

‡ Designed by Adler & Sullivan and erected in 1892.

of importance. The method shown in Fig. 783 is probably as good as any and is comparatively simple. The truss-rods are extended some 6 inches or more below the washer under the tie-beam, with a thread turned the full length. A nut is then screwed on and turned up until the truss-timbers are brought tightly together, and then a turnbuckle is screwed on as shown. The turnbuckle can be made larger at the upper end than at the lower, to allow for the difference in size of the two rods. The truss-rod, having to sustain the entire weight from the suspension-rod and also an additional stress from the truss-timbers, should be larger than the suspension-rod.

If turnbuckles cannot be readily obtained, or the stress requires a very large truss-rod, two rods may be substituted for the latter, coming down each side of the tie-beam as shown in Fig. 784, and the suspension-rod passed through the tie-beam and washer, with a head or nut on the upper end as shown. The objection to this method is that the lower washer or plate must project considerably beyond the tie-beam, and the full load from the suspension-rod and from the truss also is brought upon it.

Fig. 783. Method of Securing Suspending-Rod to Wooden Truss.

3. *Suspended Galleries or Balconies.* Galleries or balconies are often hung from trusses by suspension-rods in the manner described above, thus doing away with posts in the room below. The use of posts, however, results in a better construction, as they carry the load directly to the foundation, and by giving a rigid support to the gallery enable the latter to strengthen the wall. With rods, on the other hand, the weight of the gallery is transferred to the wall at a considerable distance above the floor, and the whole tendency of the construction is to spring the wall. Only those forms of trusses which have horizontal tie-beams should be used for suspending floors or galleries.

Fig. 784. Securing Suspending-Rod without Use of Turnbuckles.

4. *Suspended Floors and Sidewalks.* Fig. 785, which shows the manner in which the first floor, and also the sidewalk, is supported between the stone piers of the street-front of the Youth's Companion

Building,* Boston, Mass., is interesting as a detail of this class of framing. The rod is suspended from a box-girder at the second-floor level, and terminates in the nut on the under side of the steel beam from which the sidewalk-beam is hung. A short cast-iron column is slipped over the rod, with its base resting on top of the I beam, and

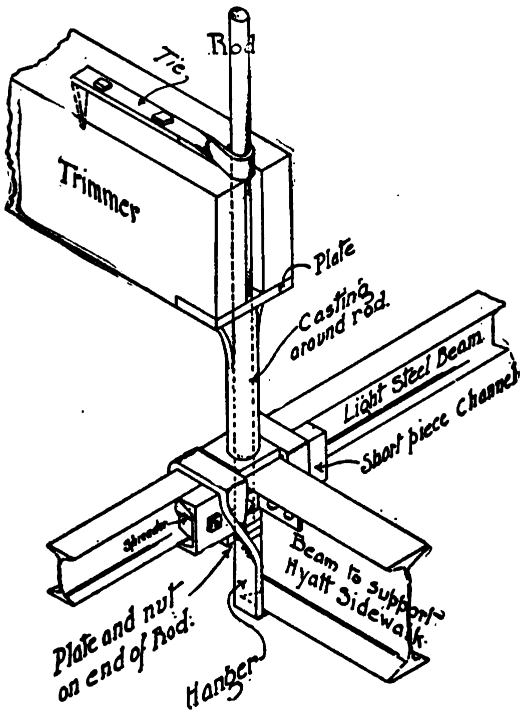


Fig. 785. Detail of Framing of First Floor and Sidewalk, "Youth's Companion" Building, Boston, Mass.

supports the end of the first-story trimmer or girder, the whole being borne by the nut on the end of the rod.

4. COMPOUND AND TRUSSED GIRDERS.

467. COMPOUND WOODEN BEAMS AND GIRDERS.† The details of the simple wooden girder have already been considered, but it sometimes happens that it is necessary to use a girder of longer span than would be safe for the deepest single beam that

* Designed by Hartwell, Richardson & Driver, Boston, Mass.

† See "Kidder's Architects' and Builders' Pocket-Book," Chapter XVII, "Strength of Built-up, Flitched and Trussed Wooden Beams."

can be obtained; and in such case, where steel beams cannot be obtained without great expense, compound wooden beams are used.

By a compound wooden beam or girder, is meant a beam built up by placing one beam on top of another and so connected that they will act as a single beam having the depth of the combined beams.

Thus, if two 10 by 10-inch beams were placed one on top of the other and the upper one loaded at the center, the beams would act as two separate beams (Fig. 786), and their combined strength would be practically no greater than if the two beams were placed side by side. If, however, the two beams can be joined so that the fibers of the lower beam will be extended as much as would be the case in a single beam of the same depth, or, in other words, so that the two beams will not slip on each other, the compound beam will have four times the strength of the single beam.

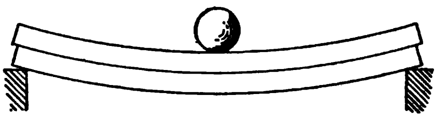


Fig. 786. Flecture of Two Beams Not Rigidly Joined.

Various attempts have been made to join beams thus placed, so as to prevent the two parts slipping on each other, but until very recently there has been no experimental data to show how far such methods accomplish their object.

During the years 1896-7, however, Prof. Edgar Kidwell, of the Michigan College of Mines, made an extended series of tests of the efficiency of compound beams of different patterns, and from

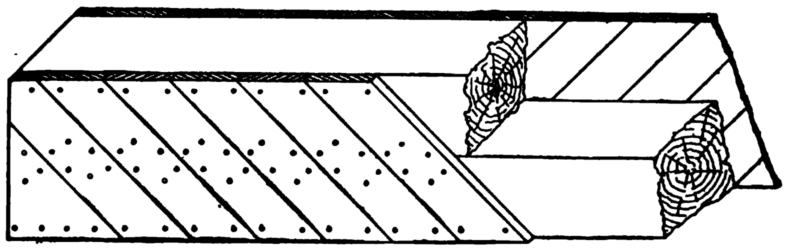


Fig. 787. Common Form of Compound Beams.

these tests much valuable data has been obtained. A full description of the tests accompanied by the conclusions of the author, and rules and data for proportioning the bolts and keys, of keyed beams, is published in the "Transactions of the American Institute of Mining Engineers," Vol. XXVII.

Probably the most common form of compound beam, as used in American building-construction, is that shown in Fig. 787, diagonal

boards in opposite directions, being nailed to each side of the two timbers to prevent their slipping on each other. Mr. T. M. Clark, in his "Building Superintendence," advocates this as one of the best forms of compound beams, and places its efficiency at about 95 per cent of a solid beam of the same depth.

Prof. Kidwell made nine tests of this style of beam, the ratio of span to depth of beam in six of them being as 12 to 1, and in three of them as 24 to 1. The shorter beams gave an average efficiency without much variation, of 71.4 per cent and the longer beams an efficiency of 80.7 per cent.

It was found that the beams failed by the splitting of the diagonal pieces or the drawing of the nails. "In every case, long before the beam broke, the struts split open or the nails were drawn partly out or bent over in the wood, thereby permitting the component beams to slide on each other. It was found that no amount of nailing could prevent this."

When built with diagonal boards 1¼ inches thick, nailed with tenpenny nails, as in Fig. 787, the working-strength of such a beam may be taken at 65 per cent of the strength of a solid beam of the same depth, and of a breadth equal to the breadth of the timbers. The deflection of the beam,

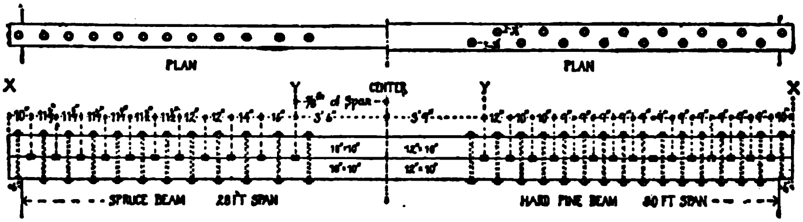


Fig. 788. Compound Keyed Beam.

however, is about double that of a solid beam of the same size, and on that account this type of beam is not to be recommended for supporting floors with plastered ceilings or for carrying plastered partitions.

468. KEYED BEAMS.* Prof. Kidwell also tested several styles of keyed beams, with the result that a compound beam keyed and bolted together, as shown in Fig. 788, was found to be the most efficient form that it is practicable to build.

It was found that with oak keys it was possible to obtain an efficiency for spruce beams of 95 per cent, while the deflection varied from 20 to 25 per cent more than would be expected in a solid beam.

By using cast-iron keys the deflection was found to be but little, if any more, than with a solid beam. The keys must be wedge-shaped, as shown in Fig. 789, so that they can be driven tightly against the end wood.

* See Kidder's "Architects' and Builders' Pocket-Book," Chapter XVII, "Strength of Built-up, Flitched and Trussed Wooden Beams."

Prof. Kidwell recommends that for ordinary purposes an efficiency of 75 per cent be allowed when oak keys are used and 80 per cent when the keys are of cast iron. The width of oak keys should be twice their height. Numerous small keys closely spaced gave better results than fewer large keys. In the middle of the span a space equal to about one-quarter of the length of the beam should be left free of keys, bolts, etc. In his report, Prof. Kidwell also gives formulas for the number and spacing of the keys.

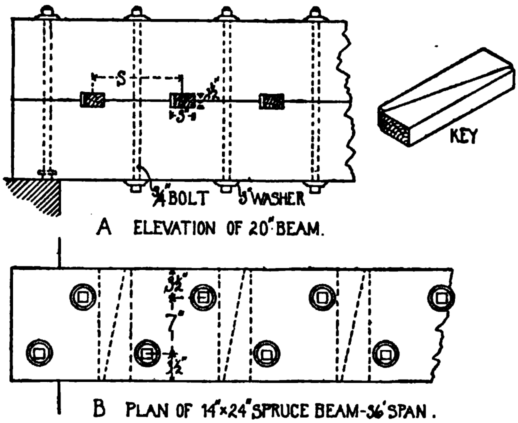


Fig. 789. Details of Keyed Beam.

As compound beams, if used, would probably be built of either 8, 10, 12 or 14-inch timbers, the author prepared a table giving the size of keys and the number required on each side of the middle and their minimum spacing, as well as the size of bolts and washers to be used for such beams vary in spans from 20 to 36 feet; noting that the maximum load that may be allowed for such beams should be taken at 75 per cent of the load as computed by the formula,

$$\text{safe load in pounds} = \frac{2 \times \text{breadth} \times \text{square of depth} \times A}{\text{span in feet.}}$$

This is the formula for beams supported at both ends and loaded with a uniformly distributed load. The term A is the "constant" or "coefficient" for beams. It denotes the safe load for a unit-beam one inch square in cross-section, one foot in length and loaded in the middle of the span; and its value is found for different woods and other materials by dividing the safe unit fiber-stress for flexure by 18.*

The number and spacing of oak keys required on each side of the center of beams of white pine, spruce, Douglas fir and long-leaf southern yellow pine, for the depths of beam shown, and the proper sizes of the bolts and washers are as follows:

* See Kidder's "Architects' and Builders' Pocket-Book," Chapter XVI.

Beams and Keys.	Bolts.	Washers.	White pine.	Spruce.	Douglas fir.	Long-leaf yellow pine.
16-inch beams 1½x8 -inch keys.	¾-in.	3 -in.	7	8	11	12
20- " 1½x3 - "	¾- "	3 - "	9	11	13	15
24- " 2 x4 - "	⅞- "	3½- "	8	9	12	13
28- " 2¼x4½- "	⅞- "	3½- "	9	10	12	14
Minimum spacing of keys.						
1½x3 -inch keys..............	¾-in.	3 -in.	11¼ in.	11¼ in.	9 in.	9 in.
2 x4 - "	⅞- "	3 - "	15 "	15 "	11½ "	11½ "
2¼x4½- "	⅞- "	3 - "	17 "	17 "	13 "	13 "

The breadth or thickness of compound beams should be not less than two-fifths of the depth. The number of keys required is not affected by the length or breadth of the beam, if the beam is figured for the full safe load.

In spacing the keys (Fig. 789) they should not be closer than the minimum spacing given in the table. For beams loaded at the center, the spacing of the keys should be uniform from X to Y, Y being one-eighth of the span from the center. If the distance between the keys, center to center, works out less than the minimum spacing, the safe load should be correspondingly reduced or the thickness of the beam increased.

For beams uniformly loaded, the first four or five keys from the ends should be spaced for minimum spacing, and the spacing of the remaining keys increased toward the point Y. When the ratio of depth to span is greater than 1 to 16, the inner keys may extend a little more than one-eighth of the span from the center for distributed loads.

Fig. 788 shows the proper spacing of keys for a 20-inch spruce beam of 28 feet span and for a long-leaf southern yellow pine beam of 30 feet span. The following schedule gives the proper spacing of keys for spruce beams (figured from the end of the beam) of longer spans. For other woods and spans the spacing should be made as nearly like these as the fixed conditions will permit. Examples of key-spacing are given below for four different depths and four spans.

The sizes of bolts and washers to be used are given above. If the beam is not over 10 inches wide the bolts may be arranged as for the spruce beam, Fig. 788; if 12 inches wide or over the bolts should be staggered as shown for the hard-pine beam. In a very wide beam the bolts might be spaced as in detail B, Fig. 789.

Spacing of keys in inches, commencing at end, for distributed load:

16-inch Spruce Beam,	32 feet span.	10, 12, 12, 16, 19, 24, 32.
20- " " "	32 "	10, 11½, 11½, 11½, 12, 12, 12, 13, 15, 18, 24.
24- " " "	36 "	13, 15, 15, 15, 15, 16, 18, 20, 30.
28- " " "	36 "	15, 17, 17, 17, 17, 17, 17, 17, 17, 17.

469. TRUSSED BEAMS AND GIRDERS. 1. *General Construction.* While compound beams may be advantageously used under certain conditions, it will generally be fully as economical and much better where there is sufficient height, to use a trussed girder of one of the types described below; and when the span exceeds 30 feet these are generally the only kinds of wooden

girders that will afford the necessary strength. Although steel I beams, plate girders, box girders and steel trusses of light, rolled sections have of late years supplanted flitched beams, built-up

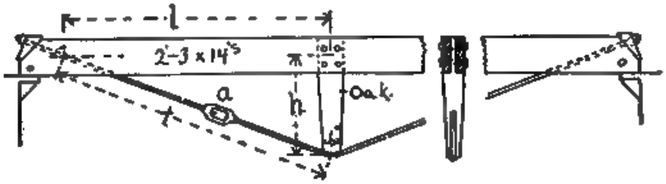


Fig. 790. Single-Strut Trussed Beam.

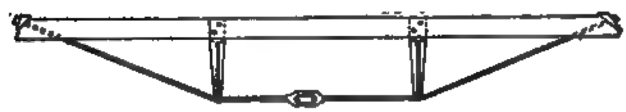


Fig. 791. Double-Strut Trussed Beam.

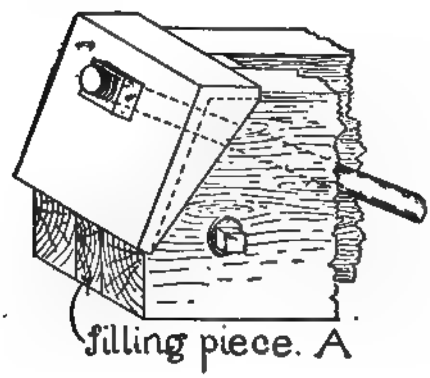


Fig. 792. Details of "Belly-Rod" Trussed Beam.

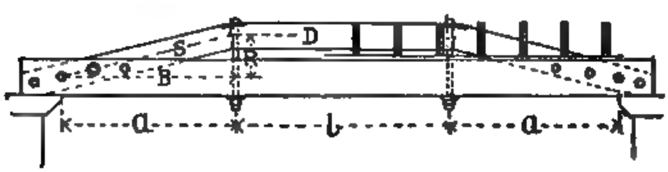


Fig. 793. Shallow Trussed Girder.

wooden beams and trussed beams and girders, the latter forms are occasionally used in some sections of the country; and a brief statement of the principles of this wood construction may be found of

service and the use of the construction itself convenient and economical.

The most common method of trussing wooden girders is by the use of a "belly-rod," as shown in Figs. 790 and 791, the former being a single-strut trussed beam and the latter a double-strut trussed beam.

Such girders, however, are often very carelessly used and without any consideration of the manner in which the pieces are stressed. The most common fault found in such girders is that the rod is not large enough, and is not placed at a sufficient depth below the girder.

The author has seen a pair of beams trussed with a rod which did not go below the bottom of the beams, and others in which the rod passed only a very short distance below. Solid wooden beams, with the possible exception of oak beams, generally commence to fail by the crushing of the upper fibers, showing that the tensile strength of the wood is greater than its crushing-strength; hence any addition to its tensile strength is superfluous unless the upper fibers, also, are strengthened. A truss-rod, placed *within* the depth of a long beam, may make it stiffer, but cannot materially increase its strength.

The proper use of a belly-rod requires such a relation of the depth, *h*, Fig. 790, to the span, that the beam will have to resist the crushing stress, only, on the girder, while the rod sustains all of the tensile stress.

Rules for determining the stresses in trussed beams and girders are given in Kidder's "Architects' and Builders' Pocket-Book" and in other handbooks. In general, the magnitude of the stress in the tie-rod is proportionate to the ratio of the length *t* to the height *h* (Fig. 790). The more nearly the distance *h* approaches the length *t*, the less will be the stress in the rod. The distances *l*, *h* and *t* should be measured from the center-lines of the pieces.

The best method of constructing a short trussed girder is that shown in Fig. 790. The beam is made of two timbers, spaced about 2 inches apart, or enough to allow the rod to go between them. A cast-iron plate, of which a larger view is shown at *A*, Fig. 792, should be placed over the ends of the beams to hold the nut or head of the rod. The strut, if made of wood, should be cut out of a large timber and tapered as shown, a tenon being cut on the upper end to go between the beams. This tenon should be secured by bolts passing through the beams. Only oak or selected hard pine should be used for making this piece.

Iron struts look neater, as they may be made much lighter in appearance. If iron struts are used they should be made in the form shown at *B*, Fig. 792. The rod should be bent to the correct angle before it is put in place, and, unless a sleeve-nut is provided, should have a nut at each end, so that the rod may be tightened without drawing over the end of the strut. Al-

though not absolutely necessary, there should be at least one sleeve-nut to assist in tightening the rod in case there is any settlement caused by the shrinkage of the timber. If the stress in the rod is found to be greater than 24,000 pounds it will be better and more economical to use two rods instead of one. When two rods are used the beam should be divided into three pieces, so as to leave two spaces for the rods. For trusses of over 20-feet span, two struts should be used, as shown in Fig. 791. By using two struts the stresses in both the beam and tie are materially reduced, provided the same depth is given to the truss.

In computing the size of the beam it should be remembered that this acts both as a strut and as a simple beam. The span for the beam, however, is only from the bearing to the strut, or between the struts, if two are used, as one strut divides the beam into two beams, and two struts divide it into three beams and these struts transmit the load to the rod. When girders are trussed in this way the joists must either rest on top of the girder or be hung in stirrup irons or joist-hangers.

2. *Special Form for Shallow Girder.* When it is desirable that the girder shall project as little as possible below the ceiling, the form of trussed girders shown in Fig. 793 may be used to advantage. A cross-section through this girder, drawn to a larger scale, is shown in Fig. 794. This is an economical method of trussing, as only short rods and bolts are used, which can be made in almost any village. The top of the truss, also, may be kept flush with the floor-joists, and a good bearing for the latter still be afforded.

Fig. 794. Cross-Section of Girder.

The principal requisites in the design of such a truss are maximum depth and the development of the full strength of the joints. It should be remembered that the depth and length of each member of any truss are measured from the center lines of the members. In order to get the full benefit from the trussing, the pieces *S* and *B*, Fig. 793, must be joined in such a way that the full horizontal component of the thrust in the piece *S* shall be transmitted to the beam *B*, and neither timber be materially weakened. This is best accomplished by making the beam *B* in two pieces, as shown in Fig. 794, and letting the strut *S* pass between them. The three pieces should then be well bolted together.

The rods transmit only a direct load, and usually are not very large. They must be provided, however, with a heavy cast-iron plate or washer at the bottom, to support the beams, and either a cast-iron or wrought-iron bent-plate washer at the top.

The girder shown in Fig. 793 is an example of one designed for a clear span of 18 feet. The total depth of the girder was limited to 28 inches, 12 inches for the joists, 14 inches for the beam *B*, with 2 by 3 pieces between them. The depth of *D* was 10 inches, which gave 16 inches for

the height *R*. The lengths of *S* and *B*, by measurement on center lines, were found to be 68 and 66 inches, respectively.*

5. JOINTS IN HEAVY WOODEN FRAMING.

470. COMMON TIMBER JOINTS. The joints commonly used in framing the walls and partitions of wooden buildings have been described in Chapter II, and those common to interior work and joinery in Chapter V. Figs. 795 and 796 of this chapter illustrate the joints generally used in heavy, wood framing.

Fig. 795 shows a number of common timber joints. "Single notching" is shown at *a* in which the post is not cut, "double notching" at *b* in which both the post and side-pieces are notched, "halving" at *c*, a "butt-joint" at *d*, a "bevel-joint" at *e*, a "housed joint" at *f*, a "cogged joint" at *g*, "dovetailed halving" at *h*, a "dapped joint" at *i*, a "double-stepped joint" at *j*, a "beveled-washer joint" at *k*, a "head-block joint" at *l* and a "bird's-mouth joint" at *m*.

471. COMPRESSION AND TENSION JOINTS. Fig. 796 shows common "strut-and-beam" joints, "compression-joints," "tension-joints" and joints used for both compression and tension. Drawings *a*, *b* and *c* illustrate the usual methods of framing wooden beams and girders into wooden posts. (See also Arts, 457 to 460, and Articles 475 to 487 relating to "Mill-Construction," all in this chapter.)

In *a*, showing two wooden girders framed into a wooden post and resting also on two steel angles bolted through the post and spiked to the under side of the girders, the post should not be reduced at its smallest cross-section to such an extent that the unit-compressive or bearing-stress is greater than that allowed for safe end-bearing for the kind of wood used. Joint *b* shows a joint similar to that shown in *a*, except that wooden blocks take the place of the steel angles and additional wooden blocks are placed on the other two sides of the post and in line with the girders. The lower blocks are "housed" into the post through which they are bolted and assist in the support of the girders. The upper blocks are bolted through the girders. The lower blocks transmit the girder-loads to the post through their lower ends, and as the lines of action of the resultants of pressure at the top and bottom of the block pass through the middle of areas of different widths, they do not coincide and consequently form a "mechanical couple," the moment of which is equal to the load from the girder multiplied by the normal distance apart of these lines of action. These couples tend to turn the lower blocks outward at the top and the tendency is resisted by

* For formulas and methods of calculating the stresses in the members of trussed beams of this and other forms, the correct dimensions of the different parts and illustrative examples worked out in detail, the reader is referred to Kidder's "Architects' and Builders' Pocket-Book," Chapter XVII.

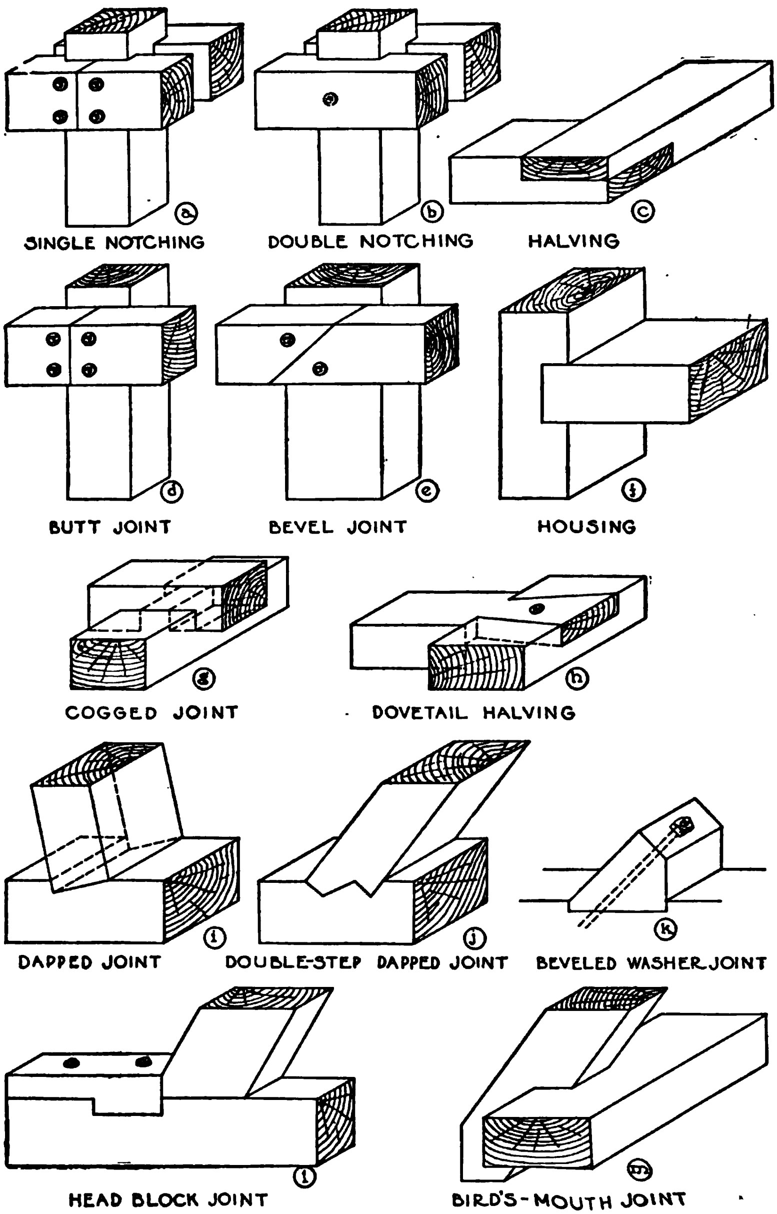


Fig. 795. Common Timber Joints.

other couples tending to cause revolution in the opposite direction and consisting of the tensional stress in the bolts multiplied by an arm which is equal to two-thirds the vertical distance from the bottom of the block to a point halfway between the two bolts. The washers used with the bolts should be so designed that the tensional stress in the bolts shall not develop a greater side-grain unit compression-stress than that allowed for the kind of wood used. Joint *c* shows a framing of wooden post and girder similar to that of joints *a* and *b*, with the end-bearing area of the girders increased by channels or bent plates spiked to the under side of the girders. They transmit the girder-loads through bolts to the steel side-plates which in turn transmit the loads through additional bolts passing through the post.

Drawing *d* of Fig. 796 shows what is known as a "dapped compression-joint." The load is transferred from the middle timber to the two outside timbers through the intermediate block which is notched into the latter and secured by four bolts as shown. The length of the block in the direction of the timbers must be such that it cannot shear along sections in the plane of the sides of the middle timber. Hard woods, such as white oak are used for the blocks. The depth of the notching into the side timbers is determined by the required bearing-surface for safe compression for the wood used for the timbers. The outside timbers usually have the same cross-section as the middle timber. When, however, the slenderness-ratio, that is, the ratio of the length to the smaller dimension of the cross-section, of the outside timbers considered as columns is greater than that for the middle timber, the sizes must be proportioned to satisfy the column-formula. The bolts and washers are for the purpose of clamping the joint tightly and holding the block firmly in place. Drawing *e* is a detail of a "half-lap compression-joint," with wood pieces or plates bolted on the sides through the joined timbers and called "fishplates."

The rest of the drawings, *f* to *r*, of Fig. 796, with the exception of *j* and *k*, are examples of "tension-joints." Joints *i*, *j* and *k* are used for both compression and tension, and sometimes for flexure. Joint *f* represents a "simple bolted tension-joint" for timbers. The sum of the cross-sectional areas of the two outside pieces is equal to the section-area of the middle piece. Cast-iron washers of standard size and shape are generally used with these joints as the bolts are not subjected to tension, but to shear, flexure and compression or bearing. Tables have been compiled for these and other types of joints giving the safe bearing, safe uniform load, and safe stresses for shear, tension and resisting moment for bolts of different diameters from ½ an inch to 3 inches and for timbers from 1 to 10 inches or more in width. The safe bearing-loads of the bolts on the end-grain and side-grain are usually based upon a safe end-grain bearing of 1000 and on a safe side-grain bearing of 100 pounds per square inch. For flexure of the bolts the safe uniform loads are usually based upon an extreme safe fiber-stress of 22,500 pounds per square inch. Other unit stresses used in these tables are, for tension in the bolts, 16,000 and for shear, 10,000 pounds per square inch. Safe loads for other allowed unit stresses may be obtained by proportion. Bolts of circular cross-section are generally used, although those of square section are occasionally employed when the question

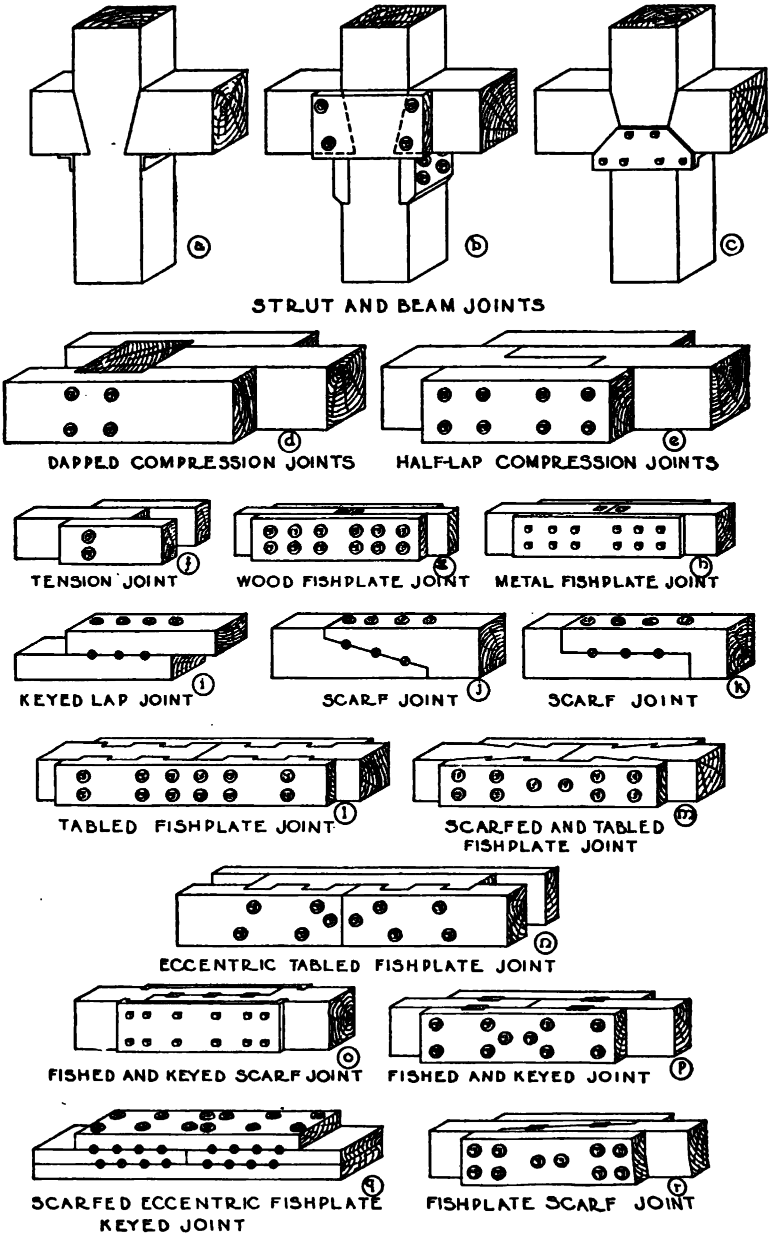


Fig. 796. Compression and Tension Timber Joints.

of cost is not considered. These square-section bolts present a greater relative bearing-area against the wood and in the case of several bolts reduce the required number. The flexure of the bolts is disregarded in the joint-design when the thickness of the timbers is less than 3 inches. The bolts should always be made to pull the timbers as tightly together as possible to resist any tendency of the side pieces to buckle and also to assist in keeping out moisture.

Drawings *g* and *h*, of Fig. 796, are "plain fishplate joints," the side plates being of wood in *g* and of metal in *h*. The methods used in designing the two joints are similar except that the bearing and other strength-values for the metal fishplates must be taken into account.

Drawing *i* is a "simple lap-joint" with four bolts and three round hard-wood or metal keys, used to increase the resistance of the bolts to shearing. Joints of this kind have relatively little strength, but because they are cheap and easily made they are used for temporary construction.

Drawings *j* and *k* are what are known as "scarf-joints," and connect the timbers longitudinally by means of bolts and keys, the wood being cut in different ways as shown. These joints are used for both tension and compression-members. They are more efficient for members in which the predominating stresses are those of compression but in which an occasional reversal of stress to tension takes place. For tension, however, the fishplate joint is more efficient. These scarf-joints are sometimes used to resist flexure.

Drawings *l*, *m* and *n* are "tabled joints" used to transmit tension in heavy, permanent, timber-construction in which the best styles of tension-joints are required. In *l* is shown a "tabled fishplate joint" in which the outside plates transmit the full tension of the middle timber across the joint by means of the rectangular projections of the members into each other. These projections are called "tables." Four tables are shown in each fishplate, two on either side of the middle of the joint, and their length is determined by the shearing-resistance of the wood parallel to the grain. In the plain fishplate joints, shown in *g* and *h*, the bolts transmit stresses by flexure, but in the tabled fishplate joints they transmit them by tension. Mechanical couples are formed by the forces of tension in the fishplate and of compression upon the shoulders of the tables which are resisted by other couples acting in an opposite direction and formed by the forces of tension in the adjacent bolts and of compression parallel to the bolts in the adjacent portion of fishplate and middle timber.*

Drawing *m* shows a "scarf-tabled fishplate joint" which is a modification of the joint shown in *l*. It will be noticed, in comparing these two joints that in *l* the bolts pass through the section of minimum cross-sectional area of the middle timber or of the fishplate, while in *m* they do not pass through these minimum areas. For this reason, in the latter joint, the area of the bolts is not always deducted from the timber-areas in designing it for

* Full discussions of the mechanical principles involved in the design of heavy, timber joints and illustrative examples showing the practical application of these principles to actual problems of construction will be found in the various architects' and engineers' hand-books.

sufficient strength. On account of the additional labor required in carefully cutting and fitting the pieces this joint is relatively expensive.

Drawing *n* shows an "eccentric, tabled, fishplate joint," in which one outside timber is continuous and the other outside timber is spliced by the middle piece. Three of the timbers are "tabled" and all four are securely bolted together.

Drawings *o, p, q* and *r* illustrate other types of "fished joints" and "keyed joints," *o* and *r* being "scarfed," *o* having metal fishplates with the ends let into the timbers and the others having wooden fishplates. In *q* the keys are circular in cross-section and in the others they are rectangular. The arrangements of the bolts are the ones usually employed. Drawing *q* shows an "eccentric joint," as one outside timber is continuous and the other outside piece is a short splice for the two middle timbers.

472. WOODEN-TRUSS JOINTS. These joints include many of those considered in the two preceding articles. For other joints common to wooden trusses, in all their design and detailed construction the reader is referred to Kidder's "Building Construction and Superintendence, Part III, Trussed Roofs and Roof Trusses" and Kidder's "Architects' and Builders' Pocket-Book," Chapter XXVIII.

6. SIDEWALK-PLATFORMS, BRIDGES AND SHEDS.

473. SIDEWALK-PLATFORMS AND BRIDGES. In many cities the building codes require the construction of sidewalk-platforms, bridges and sheds along the street-fronts of building-operations for the protection of passing people. Figs. 797,* 798 * and 799 † show the form, dimensions and details of common types of such structures as they are usually built.

Fig. 798 is an elevation and 797 a cross-section of one type of sidewalk and bridge which are constructed in the following manner:

The material used is generally yellow pine. The example shown is 10 feet in width and 14 feet in height. For the platform the uprights are 12 by 12 inches in section, set 8 feet on centers; the plates 12 by 14 inches; and the sills 6 by 12 or 12 by 12 inches, securely bolted to both sides of the uprights. All pieces are well bolted together and braced at all angles by 2 by 6-inch planks securely spiked. The floor of the platform is made of 4 by 12-inch planks laid flatwise and well spiked to 10 by 12-inch cross-timbers set 4 feet apart and well spiked to the plates. The bridge under the platform is made of 3 by 12-inch planks laid flatwise and well spiked to either 6 by 12-inch sills or to 6 by 8-inch cross-timbers set 4 feet apart

* Redrawn and adapted by permission from Professor C. P. Warren's "Plates on Building-Construction."

† Reproduced by permission from a special circular relating to "Sheds over Sidewalks," issued by The Bureau of Buildings for the Borough of Manhattan, New York City, February 5, 1910.

and spiked to sills. Suitable steps are provided at each end as shown. A strong hand-rail, also, is usually placed along the outside of the steps and bridge, all well braced, bolted and fastened. Over the bridge is a roof of 2 by 9-inch planks laid double and with a 12-inch pitch and spiked to the uprights.

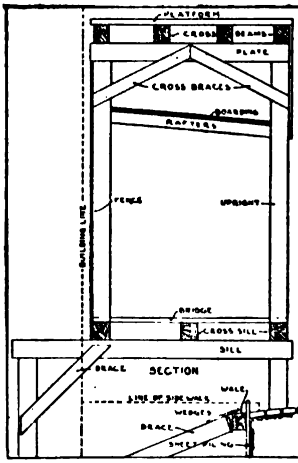


Fig. 797. Sidewalk-Platform and Bridge. Section.

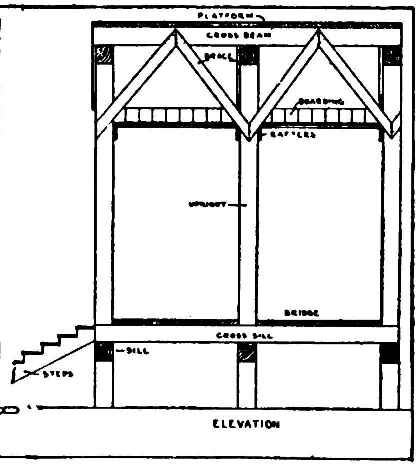


Fig. 798. Sidewalk-Platform and Bridge. Elevation.

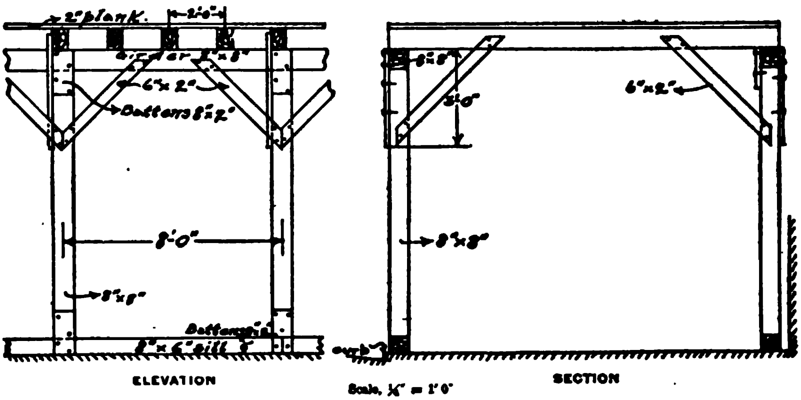


Fig. 799. Shed Over Sidewalk.

474. SHEDS OVER SIDEWALKS. Fig. 799 shows an elevation and section of a portion of a shed over a sidewalk designed in accordance with the requirements of the Bureau of Buildings for the Borough of Manhattan, New York. The general requirements are as follows:

The shed must extend from building-line to curb and must be erected as soon as practicable after the building-operation is started and must be completed before any part of the construction is carried more than 35 feet above the curb. The material must be good sound timber and all work must be done in a substantial manner and securely bolted or spiked. The girders and sills are fastened to the posts by means of battens not less than 2 inches thick and with not less than two twentypenny spikes in each member connected. The structure is braced by means of knee-braces both longitudinally and across, at every post; the braces are placed at an angle of about 45 degrees and connect with the posts, beams and girders; and the point of connection with the posts is not less than 3 feet below the top. The braces are not less than 6 by 2 inches in cross-section and there are not less than two twentypenny spikes in each member connected. The flooring is spiked to the cross-beams by a sufficient number of twentypenny spikes to hold the flooring securely in place.

For buildings exceeding 100 feet in height, and where the sidewalks are 10 feet or less in width, the beams are not less than 10 by 3 inches in cross-section and spaced not to exceed 2 feet on centers; girders not less than 8 by 8 inches; posts not less than 8 by 8 inches, spaced not to exceed 8 feet on centers; sills not less than 8 by 6 inches, and flooring not less than 2 inches in thickness.

For buildings exceeding 100 feet in height, and where sidewalks are more than 10 feet in width, the beams are not less than 10 by 4 inches in cross-section, spaced not to exceed 2 feet on centers; girders not less than 8 by 8 inches; posts not less than 8 by 8 inches, spaced not to exceed 8 feet on centers; sills not less than 8 by 6 inches, and flooring not less than 2 inches in thickness.

For buildings exceeding 65 feet and less than 100 feet in height, and where sidewalks are 10 feet or less in width, the beams are not less than 8 by 3 inches in cross-section, spaced not to exceed 2 feet on centers; girders not less than 8 by 8 inches; posts not less than 8 by 8 inches, spaced not to exceed 8 feet on centers; sills not less than 8 by 6 inches; and flooring not less than 2 inches in thickness.

For buildings exceeding 65 feet and less than 100 feet in height, and where sidewalks are over 10 feet in width, the beams are not less than 10 by 3 inches in cross-section, spaced not to exceed 2 feet on centers; girders not less than 8 by 8 inches; posts not less than 8 by 8 inches, spaced not to exceed 8 feet on centers; sills not less than 8 by 6 inches; and flooring not less than 2 inches in thickness.

These requirements are for ordinary conditions. If extraordinary loads are to be placed on the shed, heavier timbers are used. Deviations from the requirements are permitted, provided the same strength of construction is secured; but all such cases have to be reported to the chief inspector or superintendent for approval.

The general requirements for sheds over sidewalks in other cities vary in some details from those given above and taken from the building code of the Borough of Manhattan, New York; but they all agree in essential particulars.

7. MILL-CONSTRUCTION.*

475. GENERAL PRINCIPLES AND DEFINITIONS OF MILL-CONSTRUCTION. Within the past few years, it has become quite common to frame the floors of mercantile, factory and warehouse-buildings, and sometimes of office-buildings, according to the method known as "mill-construction," sometimes called "slow-burning construction." While mill-construction should be slow-burning, it differs widely from slow-burning construction as now defined in some of the building ordinances. Mill-construction applies only to those buildings in which no small timbers are used, and in which the floor-beams and girders have a sectional area of at least 72 square inches and the posts a sectional area of at least 64 square inches; while in slow-burning construction, floor-joists of much less sectional area are used, and the slow-burning result is obtained by protecting all woodwork with metal lath and plaster, plaster-boards, or other equally fire-resisting materials and by placing fire-stops wherever practicable. The actual construction required by building ordinances for slow-burning buildings is the same as for the ordinary construction, described in Arts. 455 to 463, although ordinary wood partitions or wood furrings of all kinds are not permitted.

476. ESSENTIAL REQUIREMENTS OF MILL-CONSTRUCTION. The essential requirements of mill-construction, in regard to its resistance to taking fire, retarding the progress of flames and preventing the building from being totally destroyed in case a fire gains headway, are, that all the pieces of the wooden construction shall be of large dimensions and so arranged that there will be no spaces for flame to pass through, and no opportunity for dust and dirt to collect. The underflooring should be plank, the floor-beams and girders should be self-releasing from the walls and the posts should not depend entirely upon the beams and girders to keep them in position. No furring of any kind, except metal lath and plaster, should be used in the building, and all partitions should be of incombustible materials. When ceilings are desired, they should be of metal lath and plaster placed directly against the beams and floor-planks, without air-spaces and should follow the contour of the ceiling. Large timbers and thick flooring are slow to take fire and burn very slowly. The avoidance of air-spaces greatly retards the spreading of a fire and enables the firemen to

* The editor is indebted for most of the data on Mill-Construction to Mr. A. P. Stradling, Superintendent of the Survey Department of the Philadelphia Fire Underwriters' Association, Philadelphia, and Associate Editor of the Chapter on "Wooden Mill and Warehouse-Construction," in Kidder's Architects' and Builders' Pocket-Book.

direct streams of water against all parts of the burning construction.

477. FIRST EXAMPLES OF MILL-CONSTRUCTION. Mill-construction, as the term signifies, was first used in mills and in large woolen and cotton-mills of New England, and advocated by the Boston Manufacturers' Mutual Fire Insurance Company, of Boston, Mass.

478. THE FLOORS OF MILL-CONSTRUCTION. Fig. 800 shows the manner in which the floors are constructed and supported in mills built on this principle. The posts are spaced 8 feet apart, endwise of the building, and from 20 to 25 feet the other

Fig. 800. Example of Mill-Construction.

way. There are no longitudinal girders, the floor-beams, which are usually 12 by 14-inch long-leaf yellow pine timbers, resting on post-caps as shown. The underfloor on the beams is constructed of 3-inch planks, each not over 9 inches wide, planed both sides and grooved on both edges. The grooves are filled with strips of hard pine, called "splines," about ¾ of an inch by 1½ inches in cross-section. The splines take the place of the tongues in matched boarding. In nailing the planks, it is better to blind-nail them, after the manner of nailing matched flooring in dwellings, as this allows the planks to shrink or swell without cracking and without splitting the splines. The planks are two bays in length, breaking joints at least every 3 feet. The overflooring is generally of some hard wood, usually maple, from 1 to 1¼ inches in thickness, matched, and should be laid diagonally to the planks, affording a smoother surface, and a

better distribution of the load. Between the underfloor and the overfloor or "wearing floor," should be placed three thicknesses of tarred paper, mopped with pitch or other approved materials, and laid so as to break joints. The edges of the planks should be kept clear of the faces of the brick walls by about ½ an inch, to prevent the cracking of the latter by the swelling of the planks. These cracks should be covered by light battens both above and below.

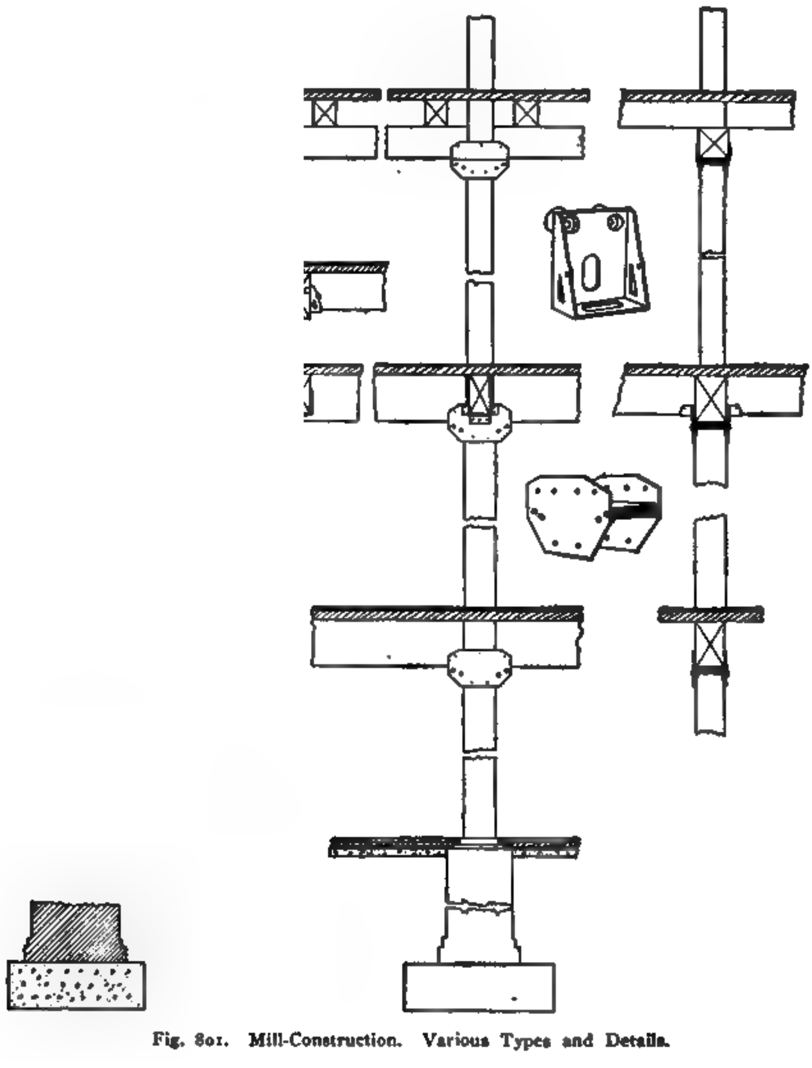


Fig. 801. Mill-Construction. Various Types and Details.

479. WOODEN POSTS IN MILL-CONSTRUCTION. In the original mill-construction, the posts were usually made circular in cross-section and tapered, and each post in the upper stories, instead of resting on the cap of the post below, either rested on the girder or on a cross-shaped "pintle" cut in between the ends of the girders. These methods have now given place to those using posts of square cross-section and resting on large bearing-plates, as shown in Figs. 754, etc.

480. TYPES AND DETAILS OF MILL-CONSTRUCTION. Fig. 801 illustrates various types of mill-construction now in use. The first story shows large girders with a solid, mill-floor. The girders are framed into wall-hangers so as to be self-releasing at the walls and are carried at the posts by steel post-caps. The upper posts rest directly on the post-caps, the side plates of each post-cap forming a complete tie for the girders and posts. The entire construction is securely fastened together by lag-screws. The second story shows the girders which bear on the walls, carried in wall-boxes and this construction, also, is self-releasing in case of fire. The joists are carried by the girders by means of joist-hangers of the "Duplex" or steel-hanger type. The post-caps are "four-way," that is, the girders frame in on two opposite sides and the beams at right-angles on the other two opposite sides. The brackets riveted to the side-plates for carrying the floor-beams are placed so as to bring the beams to the desired floor-level. Care should be taken that the joists are framed higher than the girders to provide for shrinkage, which, in the steel-hanger type, is greater than in the "Duplex"-hanger type. The third story shows the girder carried on a wall-plate built into the wall. The girder is beveled at the end, so as to be self-releasing in case of fire and arranged to fall without pulling the wall over. In this particular example, the beams are carried on top of the girders, which is not considered good construction.

Factories and warehouses are often built with transverse beams placed from 8 to 10 feet apart and the spaces spanned by flooring from 4 to 6 inches thick; but the more common method is the one involving the use of one or more longitudinal girders supporting floor-beams spaced as far apart as the load will permit and preferably not less than 8 feet on centers. No metal, structural timbers should be used in a building of this type; but owing to growing scarcity of heavy lumber, it is often necessary to substitute steel beams and girders, which, in every instance, should be thoroughly fire-proofed.

Figs. 802, 803, 804 and 805 show various details of mill-con-

Fig. 802. Mill-Construction. Various Types and Details.

Fig. 803. Mill-Construction. Various Types and Details.

struction with the different designs of post-bases, post-caps, wall-boxes, wall-hangers, wall-plates and joist-hangers.

Fig. 806 shows the use of I-beam girders with wooden columns and wooden beams.

Fig. 804. Mill-Construction. Various Types and Details.

481. JOIST-HANGERS AND STIRRUPS IN MILL-CONSTRUCTION. To render the construction and particularly the

girders slow-burning, it is important that there are no hollow spaces between the upper surface of the girders and the flooring, and that the upper surface of the floor-beams is flush with that of the gird-

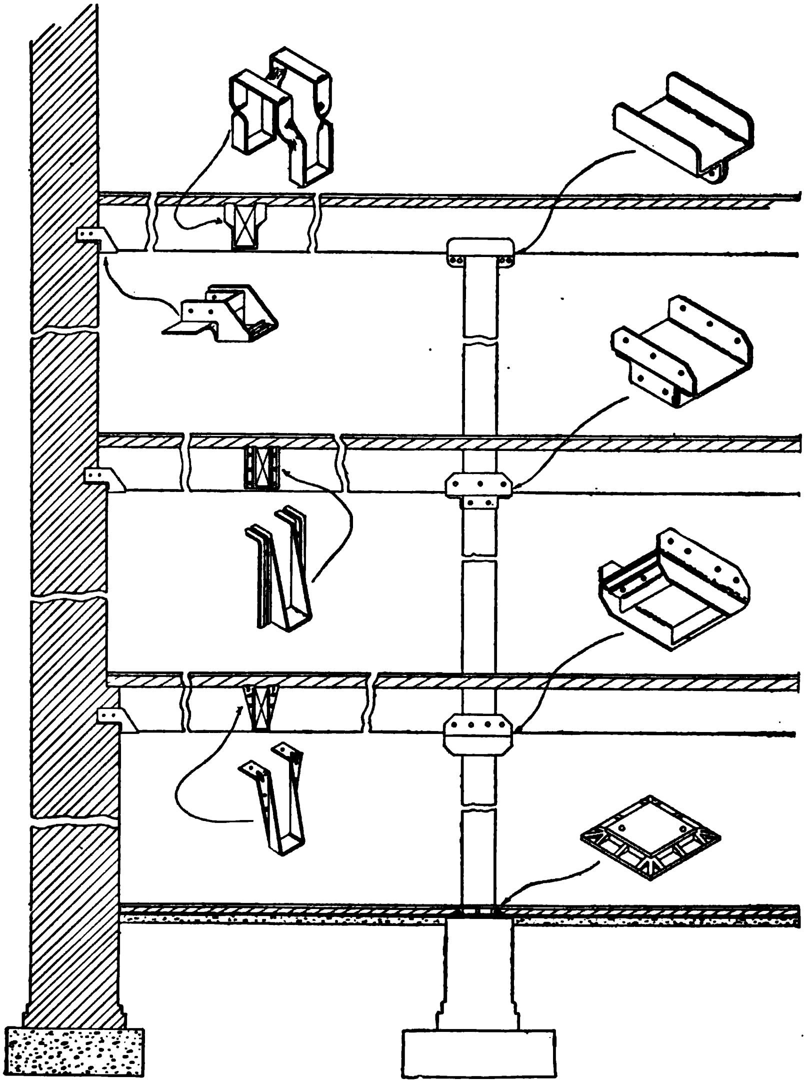


Fig. 805. Mill-Construction. Various Types and Details.

ers. This, of course, necessitates "framing" the floor-beams to the girders. For heavy construction the only kind of framing that is

Fig. 806. Mill-Construction. Steel Girders and Wooden Posts.

permissible is one in which some form of joist-hanger is used. The various forms of joist-hangers now in the market have been illustrated and commented upon in Arts. 96 to 103 and Art. 480. When the floor-beams are 6 by 12 inches, or larger in cross-section, and the girders are of wood, the author would give preference to the "Duplex" hanger.

The ends of all headers 6 feet or more in length should be carried in joist-hangers or stirrups, and in warehouses and all first-class buildings all framing should be done by means of joist-hangers. If the stirrups are employed, iron of the following sizes should be used for the corresponding sizes of joists to be supported:

Sizes of joists.	Sizes of stirrup-irons.
From 2×8 to 3×10 inches,	¼×2½ inches.
From 3×12 to 6×12 inches,	⅜×3 inches.
From 4×12 to 4×14 inches,	½×3½ inches.
From 6×14 inches,	½×4 inches.
From 8×14 to 10×14 inches,	⅝×4 inches.

Aside from the matter of strength, there are objections to the use of stirrups. If the timber on which they rest is not perfectly dry the stirrups will settle an amount equal to the shrinkage of the beam on which they rest, letting the header down with them. The projection of the iron, also, above the top of the timber necessitates cutting out the flooring, and when stirrups are exposed they do not present a neat appearance. When "Duplex" hangers are used the effect of shrinkage is reduced one-half and the other two objections to the stirrup, previously mentioned, are overcome. The "Duplex" hanger has ridges on the inside of the side brackets to hold the beam.

482. POST-CAPS, WALL-BOXES, ETC., IN MILL-CONSTRUCTION. Fig. 807* illustrates other forms of post-caps. The post-caps shown for the first-story floor and roof are of heavy cast iron. The post-cap illustrated for the middle-story posts is also of cast iron and is what is known as the "pintle-type." The girders are anchored in the wall at the first-story floor-level as shown, in wall-boxes, the middle story showing the girder in an approved type of self-releasing wall-hanger, while in the roof the ordinary wall-plate anchor is shown. Fig. 808 shows a laminated-floor construction, the construction around the post being supported on angles, which serve also to tie the girders.

The roofs of these mills are generally flat and are framed in the same way as the floors, but with lighter timbers and 2½-inch roofing-planks.

* Redrawn and reproduced by permission of Professor Charles P. Warren from his plates on the "Development of Building-Construction."

ROOFING MATERIAL TIN, GRAVEL, DUCK OR ASPHALTUM, ETC.

Fig. 807. Mill-Construction. Cast-Iron Plates, Caps, Pintles, Etc.

483. MILL-CONSTRUCTION APPLIED TO STORES, OFFICE-BUILDINGS, ETC. In applying the principles of mill-construction to stores and office-buildings, it is necessary to deviate considerably from the original mill-method of framing. In stores it is desirable to have as few posts as possible and this necessitates longitudinal girders and very often iron columns. In office-buildings it is generally practicable to locate the posts so that they will come in the partitions; and as the rooms or offices are generally about 12 or 14 feet wide, the method of framing usually adopted is that shown in Fig. 772. When the posts are placed over 8 feet apart, necessitating a longitudinal girder, it is more economical to space the floor-beams about 4 feet on centers, as this permits the use of 2-inch planks for the underflooring. If the building is several stories in height it may be necessary to use iron or steel columns, as wooden posts might take up too much room for this class of buildings. If the columns or posts come in partitions, or are to be fire-proofed, the square section makes the best shape for a cast-iron column. Iron columns should always be protected with fire-proof material, as they will not stand in a fire as long as wooden posts.

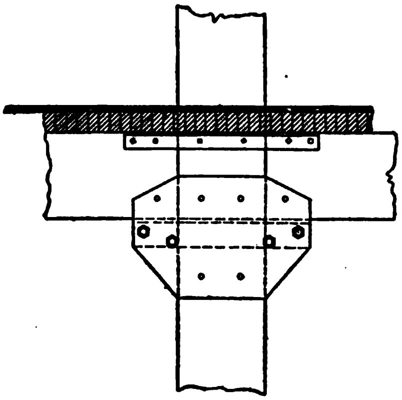


Fig. 808. Mill-Construction. Laminated Floor.

The floor-beams and girders should always be flush on top, and the former should be hung from the latter by malleable-iron hangers, steel hangers or stirrup-irons, with joint-bolts or anchors on at least every other beam. The underflooring, if of 2-inch spruce planks, will be cheaper if tongued and grooved than if splined. It is also better to lay the flooring diagonally, as this stiffens the building and gives a better surface on which to lay the finished flooring, which should run at right-angles to the beams. A layer of some fire-proof lining, such as "Salamander," should always be placed between the planks and the upperflooring or wearing-flooring in all first-class buildings.

When the span of the girders is too great to make it practicable to use wooden girders, I-beam girders are generally used. The various forms of I-beam-girder constructions are discussed in Arts. 103, 480 and 485, and the beams are suspended or attached to the

I-beam girders as illustrated therein. The girders should be covered with metal-lath and plaster. As it is practically impossible to give a neat finish to the under side of mill-floors without casing or plastering, it is generally customary, when this method of construction is used in office-buildings, apartment-houses, etc., to cover the beams and under side of the planking with metal lath and plaster. By taking a little pains in spacing the floor-beams, the ceilings of the various rooms can usually be divided into panels of equal size, which, when plastered and tinted, present a very good appearance. The plastering should be put directly on the beams and planks, and as already stated should follow the contours of the ceilings. The details of the floor and roof-framing in this form of construction are usually quite simple.

484. CALCULATING LOADS IN MILL-CONSTRUCTION. In calculating the safe loads which the girders and beams will carry, the loading should be assumed as concentrated or distributed, according to the design. Formulas for various conditions of loading on beams are given in Kidder's "Architects' and Builders' Pocket-Book."

485. SUPPORTS FOR COLUMN AND BEAM-ENDS OF GIRDERS. SPECIAL FORMS OF BOX-ANCHORS, ETC. When the beams and girders rest on the columns, they should be connected endwise, either by notching the beams over the lugs cast on the iron caps, or by bolts or wrought-iron straps. It is also desirable to have the columns bolted together endwise, as shown in the figures. When approved, steel post-caps are used, the girders and posts are tied together by means of lag-screws through the caps.

The method of anchoring and supporting the wall-ends of the beams and girders requires more consideration in this method of construction than in the ordinary method, as the beams are larger, they make a greater hole in the wall, bring a greater crushing-weight on the bricks and have a more severe effect on the wall when they fall. In a building intended to be constructed on the slow-burning principle, the floor-beams and girders should be anchored to and supported by the walls in such a way that in case the beams are burnt through the ends may fall without injuring the walls; and where large timbers are used provision should be made against the possibility of dry rot.

The "Goetz" box-anchors, Fig. 809, or the "Duplex" wall-boxes, Figs. 801 and 804 are excellent anchors and supports for large beams or girders built into the walls, as they provide a sufficient bearing-plate, support the wall above the beam, provide for free circulation of the air around the beam or girder and readily release

the same in case of fire. The "Duplex" wall-hanger, Fig. 810, or the "Van Dorn" wall-hanger, Fig. 811, accomplish the same purpose, but in different ways. Fig. 811 shows wall-hangers for brick and concrete-block walls and also joist-hangers for wood and steel I-beam joists or girders.

The "Duplex" wall-hangers, Fig. 810, are for large timbers. These hangers are made extra-heavy and are provided with wall-plates that have a bearing of 8 inches on the wall. The bearing of the timbers on the hangers is also 8 inches. For beams not exceeding 10 inches in breadth there is probably little choice between box-anchors and wall-hangers, except perhaps in price and appearance. When the wall-hanger is used, no hole is left in the wall and the saving of 6 inches in the length of the timber is effected. This, in some cases, would be a consideration. For girders 12 by 14 inches and upwards in cross-section, the author believes the hanger preferable to the box-anchor. Wall-hangers made in the form of stirrups should not be used for heavy beams. The Van Dorn Iron Works Company and other manufacturers also, make heavy wall-hangers for large timbers. Fig. 812 shows the "Lane" hangers and the "National" hanger. Illustrations *A, B* and *C* are styles of the "Lane" hanger. Other styles are made for use under special conditions. These hangers are made of plate steel of uniform width and thickness throughout. They fit closely against both the joist and header, and can be placed in buildings already built where tenons have weakened or settled. The hooks are broad and afford a liberal bearing upon the top of the header, or upon the wall, and the seat for the joist is ample. The strength of these hangers is calculated to be sufficient for the safe load allowed for yellow-pine joists, 2 by 6 inches in section and 6 feet long. Illustration *D,* Fig. 812, shows the "National" hanger which, also, is forged from mild steel. There are several other makes. The post-caps shown in Figs. 763 and 764 are for cylindrical columns and can be used either for two-way or four-way construction.

The method of supporting the wall-ends of the beams in the original mill-construction is shown in Fig. 813. The bricks are carefully built around the end of the beam, so as to leave an air-space and plenty of room for the beam to fall out without injuring the wall. This method is not patented. Over beams exceeding 12 inches in thickness it is advisable to place a flat stone or iron plate to support the wall above the beam-end. In no case should the brickwork be built directly on the wood. For a full description * of wall-hangers, wall-boxes and wall-plates see Arts. 96 to 103,

*See, also, Kidder's "Architects and Builders' Pocket-Book," Chapter XXII, "Wooden Mill and Warehouse-Construction."

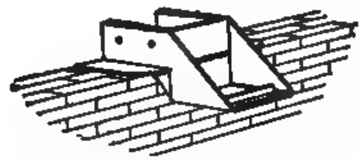


Fig. 810. Duplex Wall-Hanger for Large Timbers.

Fig. 809. Goetz Box-Anchor.

Fig. 811. Van Dorn Wall-Hangers and Joist-Hangers.

Chapter II. The different methods used in attaching steel beams and girders to wooden posts and wooden beams to steel girders is shown in Fig. 806.

486. ROOFS IN MILL-CONSTRUCTION. 1. *Flat Roofs.* As before stated, the ordinary mill-roofs are usually flat, that is,

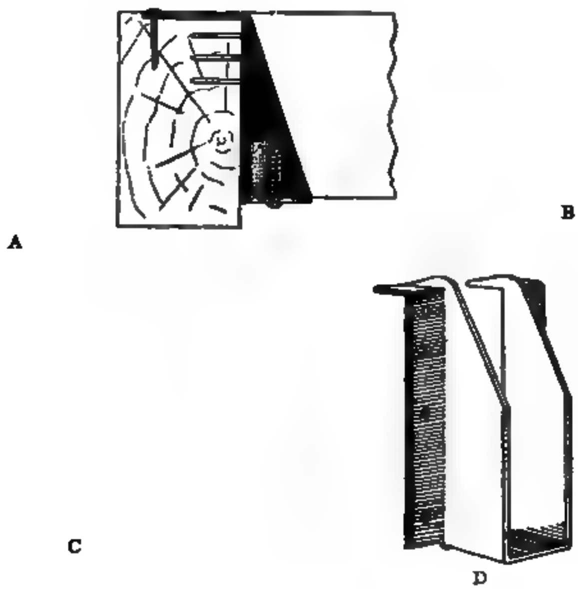


Fig. 812. Lane Hangers, A, B and C. National Hanger, D.

with a pitch of about ½ an inch to the foot and they are framed in precisely the same way as are the floors, the under side of the roof forming the ceiling of the upper story. This form of roof should be used, also, for warehouses, factories and mercantile buildings, and the same attention given to the elimination of concealed spaces that has been suggested for floor-construction. Whenever necessary for a "finish," metal lath and plaster should be used, without air-spaces, and the plastering should follow the contour of the ceiling.

Fig. 813. Early Type of Wall-End Support.

In office-buildings, hotels, etc., it is necessary to provide a ceiling below the roof to prevent the rooms in the upper story from becom-

ing too hot. This ceiling should be of metal lath and plaster and the space between the ceiling and the roof should be not less than 4 feet at the lowest point, and should be ventilated to the outside of the building by openings in the side-walls.

2. *Pitched Roofs.* Mill-construction may be used to advantage, also, in constructing the pitched roofs of churches and in buildings having finished attics. Fig. 814 shows a section through the eaves of a church-roof constructed on this principle. The rafters are made of heavy timbers spaced from 5 to 6 feet apart and covered with 2-inch matched planks. On top of the planks should be spread a layer of "Salamander" plaster, or five layers of felt paper, well saturated between each layer with pitch, about ¾ of an inch thick, which may be kept in place by horizontal strips, each ¾ of an inch by 1½ inches in section, nailed to the planking about every 2 feet. Over the plaster, shingles, slate or tile may be laid in the usual manner. The layer of plaster would diminish the danger of having the roof catch fire from the outside and also reduce the transmission of heat. The under side of the roof-planking should be furred with ⅜-inch strips and then lathed and plastered. Metal lath is of course the best. Sheathing-lath, also, may be used.

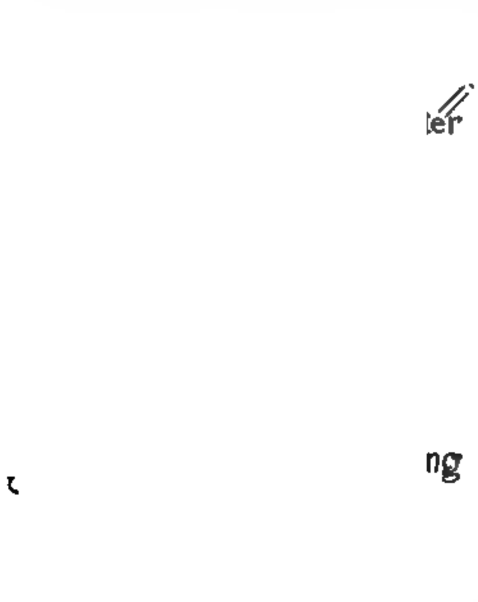


Fig. 814. Mill-Construction Applied to Church Roof.

On this coat of plaster diagonal ceiling may then be placed, if a wood finish is desired, or it may be again furred, lathed and plastered. The two thicknesses of lath and plaster, with a ½-inch air-space between undoubtedly makes the room beneath much warmer in winter and cooler in summer. If the roof-span is over 25 feet, every third pair of rafters must be trussed and purlins hung under the middle of the other rafters.

3. *Partitions in Mill-Construction.* When mill-construction is used for the floors and roofs, the partitions should be built of

1½-inch I beams or channel-bars and metal lathing and plaster, or other equally fire-resisting materials.

487. ADVANTAGES AND DISADVANTAGES OF MILL-CONSTRUCTION. Mill-construction, when intelligently carried out, undoubtedly ranks next to fire-proof construction in durability and fire-resistance, and far surpasses unprotected iron or steel in withstanding fire. It should never be weakened by placing light timbers where strength is not required; and the use of all timbers which are not "single sticks" should be avoided.

If "built-up" timbers are used, they should be planed and well bolted together and all interstices between separate pieces avoided. All timbers should be well seasoned and each column should have a 1½-inch hole bored through its axis, from end to end, with a 1-inch hole intersecting the larger one at right-angles near each end of the column. Paint should never be applied to the interior work of a building of this type until the timbers are thoroughly seasoned, and no paint, if applied at all, should be put on until at least three years after the erection of the building. "Cold-water" paint or whitewash is much preferred in buildings of this type.

In regard to the objections to or disadvantages of mill-construction, it has been found that when a fire once gains headway in a tall building constructed on this principle, it is almost impossible to save the building. The advantages of this method of construction are the most pronounced in low buildings. For this reason, the building ordinances of the different cities limit the height of buildings of this type of construction, the Philadelphia building code prohibiting it for any building whose height is over 65 feet or six stories.

CHAPTER VIII.

Specifications.

1. GENERAL CONDITIONS.

488. Importance of Complete Specifications. Too much emphasis cannot be given to the importance of complete and concise specifications for any building, for the specifications define the quality of the work and materials, and to a very large extent the cost of the building and the various questions that arise during the progress of the work. The first requisite in specifications is that they shall cover every part of the work; the second, that they shall be written in such a manner that they will be readily comprehended by the contractor and his foremen; and the third, that they shall be concise, describing as accurately as possible the quality of the materials to be used, how the work is to be done and everything, not sufficiently shown by the plans and details, that affects the cost.

It is desirable, also, that all work of the same kind or character shall be described in the same place and not scattered through the specifications. The architect should not expect the contractor, without extra compensation, to do anything not provided for in the plans and specifications, nor to do better work than the specifications call for. He must be sure, therefore, that everything he wishes done is clearly indicated in either the plans or the specifications, and that there are no loopholes for poor workmanship or inferior materials. The parts of the work to be done by each contractor, also, should be clearly stated, so that there can be no misunderstanding as to who is to do any particular thing. It often happens that some minor details, such as closing up windows, protecting stonework, drying out the building, etc., are not properly specified, and the contractors dispute over the assignment of these parts of the work much to the annoyance of the architect. Such differences are generally avoided when the entire contract for the erection and completion of the building is awarded to one person or firm; but even then it is better to have the duties of the subcontractors clearly defined.

As a rule, the form, dimensions and quantity of all constructive materials should be fully indicated on the drawings, so that only their kind and quality and the manner of doing the work need be

covered by the specifications. In regard to the finish, both exterior and interior, the wording of the specifications will depend in a great measure upon whether or not the detail drawings are made before the work is estimated or figured. If detail drawings are furnished to the contractor with the general drawings the specifications may be much abbreviated; but if such details are not made, the size of all moldings, the number and size of members and the amount of dentil-work, carving, turned moldings, etc., should be accurately described, and the detail drawings made to conform to the specifications. Free-hand sketches on the margins may be effectively used for illustrating this part of the specification. General clauses should be avoided as far as possible, as they tend to cumber a specification and to obscure the really important parts.

The following forms of specifications for the various kinds of work generally included in the carpenter's contract are offered merely as guides or reminders to architects, and are not always to be copied literally.* Figures or words enclosed in parentheses may be changed to suit special or local conditions or the preference of the architect, or may be used in place of the preceding word or words. Matter enclosed in brackets consists of notes or suggestions by the author or editor. Long dashes in text indicate omission of names of special brands, makes, patents, etc.

Every specification should be prepared with special reference to the particular building for which it is intended.

Specifications with fixed printed forms, to be used for the various trades, are by some not recommended, because it is claimed that when they are used the architect is apt to overlook important points, and that the use of such forms tends to a lack of progressiveness and of study of the construction best suited to varying requirements of different buildings. This, however, does not refer to "standard forms" for the preliminary clauses, such for example, as have been recommended by the American Institute of Architects.†

The author would recommend to the young architect that before writing or dictating his specifications he make a skeleton form, con-

* For specifications for masonwork, plastering and fireproofing, see "Building Construction and Superintendence, Part I, Masons' Work, by F. E. Kidder.

† The American Institute of Architects, prior to April, 1911, was engaged for more than four years in an effort to improve the form of certain documents currently used by architects, and to make these documents clear in thought and statement, equitable as between owner and contractor, applicable to work of almost all classes, binding in law and a standard of good practice.

The related "Standard Forms" now approved by the Institute include (1) "Invitation to Bid"; (2) "Instructions to Bidders"; (3) "Form of Proposal"; (4) "Form of Agreement"; (5) "Form of Bond"; and (6) "General Conditions of the Contract."

The Standard Documents of the American Institute of Architects may be ordered from E. G. Soltman, sole licensee for publication, Tee Square Building, 134-140 West 29th Street, New York City.

sisting of headings of the different items to be specified, carefully looking over the plans and revising this outline until everything seems to be covered and the headings arranged in their proper sequence. The specifications can then be filled out in the manner herein indicated.

Every specification should be preceded by the "general conditions" governing all contractors. These may be advantageously printed on separate sheets and used as a cover to the written specifications, but not be repeated in the latter.

The "general conditions" used by an architect in writing specifications vary more or less, according to his experience. Legal provisions relating more particularly to the carrying out of the contract should be included in the general conditions.

The following is a revision to date (1913) of the form used by the author for a number of years with satisfactory results:

489. General Conditions in Detail. The contractor is to give his personal superintendence and direction to the work, keeping, also, a competent foreman constantly on the ground. He is to provide all labor, transportation, materials, apparatus, scaffolding and utensils necessary for the complete and substantial execution of everything described, shown or reasonably implied in the drawings and specifications as belonging to the work included in his contract.

All material and workmanship are to be of the best quality throughout.

The contractor is to carefully lay out his work and be responsible for any mistakes he may make, and any injury to others resulting from them.

Where no figures or memoranda are given, the drawings are to be accurately followed according to their scale; but figures or memoranda are to be preferred to the scale in all cases of difference.

In any and all cases of discrepancy in figures, the matter is to be immediately submitted to the architect for his decision, and without such decision said discrepancy is not to be adjusted by the contractor save and only at his own risk; and in the settlement of any complications arising from such adjustment, the contractor is to bear all the extra expense involved.

The drawings and these specifications are to be considered cooperative; and all works necessary to the completion of the design, drawn on the drawings, and not described herein, and all works described herein and not drawn on the drawings, are to be considered a part of the contract, and must be executed in a thorough manner, with the best of materials, the same as if fully specified.

The architect is to supply full-size drawings of all details, and any work constructed without such drawings, or not in accordance with them, must be taken down and replaced at the contractor's expense.

Any material delivered or work erected not in accordance with the drawings and these specifications is to be removed at the contractor's expense and replaced with other material or work satisfactory to the architect, at any time during the progress of the work. In case the nature of the defects is such that it is not expedient to have them corrected, the architect is to

have the right to deduct such sums of money as he considers a proper equivalent for the difference between the value of the materials or work and the value of that specified, or for the damage to the building, from the amount due the contractor on the final settlement of the accounts.

The contractor is to provide proper and sufficient safeguards and protection against accidents, injuries or damages to any person or property during the progress of the work. The contractor, alone, is to be responsible, and not the owner or the architect, neither one of whom is to be in any manner answerable for any loss or damage that may happen to the work, or any part thereof, or for any of the materials or tools used and employed in finishing and completing the work.

The contractor, when called upon by the architect, is to produce vouchers from the sub-contractors to show that the work is being paid for as it proceeds.

All facilities, such as ladders, scaffoldings and gangways, are to be given the architect for inspecting the building in safety, and provision is to be made, to the architect's satisfaction, for protection from falling materials.

The drawings are the property of the architect and must be returned to him before the final payment is made.

The contractor is to keep the building at all times free from rubbish and shavings, and on completion is to remove all rubbish and waste material caused by any operations under his charge, clean up the house and grounds, and leave the work perfect in every respect.

[If the contractor is to pay for *insurance* on the building it should be so stated in the specifications and also incorporated in the contract.]

2. CARPENTERS' WORK. FRAME BUILDINGS.*

490. General Considerations. [As the carpenters' work required to erect a frame building and prepare it for plastering is so different from that required on a brick building, not only in framing and covering the walls, but also in the details of the window-frames and usually of the exterior finish, the author has thought it best to give separate specifications for frame and brick buildings, up to the point where such buildings are enclosed for lathing. Beyond that point, a single form of specification will answer for all ordinary buildings, whether brick, stone or frame.]

Timber. The whole of the timber used in and throughout the building is to be the best of its respective kind, full and square to the dimensions indicated, well-seasoned, free from large or loose knots, sap, shakes or other imperfections impairing its durability or strength.

Sleepers under basement-floor are to be of chestnut (black locust, cypress,

* For specifications for masonwork of all kinds, including plastering and fireproofing, see "Building Construction and Superintendence, Part I, Masons' Work," by F. E. Kidder.

pitch-pine, Douglas fir, redwood), 4 by 4 inches in section, and set 18 inches on centers.

Posts supporting porch-floors are to be of white cedar (redwood, pitch-pine, chestnut, cypress, black locust or Douglas fir), 6 inches in diameter at the smaller end.

The girders supporting first floor, the posts supporting the same and the partition-caps throughout are to be of long-leaf yellow pine or Douglas fir.

The posts, sills, girts and first and second-floor joists are to be of spruce (Norway pine, native pine, Douglas fir).

All other framing-timber is to be of eastern hemlock.

[In the East it is much better to have all the framing-timber of spruce or pine, although hemlock is largely used in some localities.]

All framing-timbers and scantlings are to be of the sizes and distances apart indicated on the framing-plans or other drawings.

[It is customary with many architects to put the sizes of all framing-timbers in the specifications, and when there are no framing-plans it is best to do this. When all of the dimensions are marked on the drawings the author believes it is better not to repeat them in the specifications.]

Any other timbers not shown on the drawings, but required to carry out the evident intent of the plans in a proper manner, are to be furnished by the contractor.

491. **Framing.** The building is to be full-frame, all framed, braced, spiked and pinned in the best and strongest manner, perfectly true and plumb and in accordance with the framing-drawings.

No woodwork is to be placed within 1 inch of the outside of any chimney and no nails are to be driven into any chimney. (See Art. 228.)

The under sides of sills and ends of girders are to be painted two coats of linseed-oil paint before they are set in place.

The sills are to be halved at the corners and spliced with a scarf-joint. All sills less than 20 feet in length are to be in one piece.

The first-floor joists are to be notched down (4) inches on the sills and mortised (2) inches more into them, bringing the bottom of the joists flush with the bottom of the sills (See Fig. 43) (or to be hung in ——— joist-hangers as shown in Fig. 42). The joists are to be sized so as to be perfectly level and in line on top, and to be framed (or to be hung in ——— joist-hangers), flush with the girders.

All are to be well spiked to sills and girders.

Joists of second and third floors are to be crowned ¾ of an inch in 20 feet, sized 1 inch on girts and partition-caps and well spiked.

[If the ceiling is not to be furred the joists, also, should be sized to a uniform width.]

The posts are to be tenoned into sills, and the girts tenoned and pinned into posts. Braces are to be 3 by 4 inches in section and tenoned and pinned into posts and into sills or girts. Each stud is to be cut with a 2-inch tenon on the lower end and is to be well spiked at the upper end with twentypenny spikes. No studs are to be spliced.

Studs at sides of all openings are to be doubled.

The plates are to be made of two pieces of 2 by 4-inch scantling, breaking joint and securely spiked to posts and studding.

The floor-joists are to be doubled under all partitions running the same way as the joists; set 4 inches apart (see Art. 107); and bridged every 2 feet with pieces of floor-joist 4 inches long, securely spiked.

All openings are to be framed around with headers and trimmers of the sizes marked on plans. The headers and tail-beams are to be hung in —— steel hangers, or stirrups.

[If special construction, such as flitch-plate headers or steel beams is required, it should be specified here.]

All headers are to be hung in joist-hangers or stirrup-irons of the required sizes.

Bridging. All floor-joists are to be cross-bridged with one row of bridging for spans of from 8 to 16 feet, and with two rows for all spans exceeding 16 feet (or where shown on framing plans), of (1 by 3-inch *) stock cut to fit and nailed with two eightpenny nails at each end of each piece.

Piazza and Porch-Floors. The piazza and porch-floors are to be framed with a (4 by 10-inch) girder from each post or pier to the house, set so that the top of the girder will be (flush) with the top of sill, and pitching away from the house 1 inch in 6 feet. Each girder is to be gained 1 inch into the whole depth of the sill and is to be secured to the sill by a 1/4 by 2 1/4-inch flat iron tie, turned over inside of sill and spiked to sill and girder with three twentypenny spikes. The outer end of the girder is to be supported on brick piers built by the mason [or on cedar (pitch pine, cypress, chestnut, redwood, black locust, Douglas fir) posts 6 inches in diameter at the top, set 4 feet in the ground and tamped with sand and gravel].

Between the girders are to be framed the (2 by 6-inch) floor-joists, set 20 inches on centers parallel to the house (and all flush on top with the girder.)

Piazza and Porch-Roofs. The roof of the front piazza is to be hipped with (2 by 8-inch) hip-rafters and (2 by 6-inch) jack-rafters, and to have a pitch of (1/2-inch) to the foot. The upper ends of hip-rafters and inner jack-rafters are to be well spiked to the wall.

The rafters are to be supported by (4 by 8-inch) plates, supported by (4 by 4-inch) uprights over the posts, which are not to be put in place until the finish-work is put up. Furring is to be put under the plates for the architrave and cornice, and is to be made of 2 by 4-inch studding, set 20 inches on centers, toe-nailed to under side of plates and furnished with a 2 by 4-inch soffit at the bottom.

The wall-ends of plates are to be firmly secured to the studding of the house.

The rear-porch roof is to have 2 by 6-inch rafters, set 20 inches on centers, and 4 by 6-inch plates.

Main Roof. The main roof of the house is to be framed as shown on framing-plan (or, in the strongest manner), with valley-rafters carried to ridges, hips and 2 by 10-inch ridge-poles. All hips and ridges are to be

* For warehouse-floors, on 14-inch joists, 2 by 3-inch stock is generally used.

maintained perfectly straight. Rafters are to be notched onto the plates and spiked. (The overhang of rafters is to be dressed on three sides and sawed to the pattern shown on detail drawings.) The rafters are to be doubled at each side of dormer-openings and 4 by 8-inch headers are to be put in, 8 feet above attic floor. (Cut in (2 by 8-inch) valley-rafters to intersect with dormer-roofs.)

Partitions are to be carried up to support roof wherever practicable, and all are to be thoroughly tied and made perfectly secure and strong. Collar-beams (2 by 4-inch) are to be spiked to each pair of rafters, 8 feet 2 inches above attic-floor joists.

Dormers. The dormers are to be framed with 4 by 4-inch corner-posts, 2 by 4-inch studding and plates, and 2 by 6-inch rafters. The studs are to be notched 1 inch onto the rafters, and extended to the floor. (See Art. 129.)

492. **Sheathing (Boarding).** The roof of front porch (which is to be tinned) is to be covered with 4-inch matched-pine (spruce, hemlock) boards, dressed one side to a uniform thickness and free from large or loose knots or knot-holes. The boards are to be nailed to every bearing with two eightpenny nails, and all uneven places smoothed with a plane.

All other roofs and all frame walls, including walls of bay windows and dormers, are to be covered with good sound hemlock (spruce, native pine) boards not over (10 inches) wide, dressed one side, laid close together and nailed to every bearing with two eightpenny nails. These boards are to be set diagonally on the walls of the house and horizontally elsewhere. Crickets are to be formed on roof, behind chimneys, to shed the water and prevent the lodgment of snow.

493. **Outside Finish.** All outside finish, unless otherwise specified is to be worked from (clear) (good) thoroughly seasoned white pine (cypress, cedar, Douglas fir, redwood) in strict accordance with elevation and detail-drawings and is to be put up in a skillful manner, with close joints and nails sunk for puttying. Joints exposed to the weather are to be matched, and painted with thick, white lead before the pieces are put together.

Cornices. The main cornice is to be supported by false rafters, sawed from (3 by 8-inch) white pine (cypress, cedar, redwood), free from large or loose knots, dressed on two sides and securely fastened to the plates and rafters by fortypenny spikes. Plank headers are to be cut between the common rafters, to secure the ends of false rafters, where necessary.

Rafter-ends are to be spaced uniformly (20 inches) on centers. A 10-inch, molded, frieze-board is to be put on the walls, directly under the rafters, and an 8-inch board is to be cut between the rafters and against the frieze, and is to be gained 3/8 of an inch into the rafters.

The overhang of eaves is to be covered with 4 by 7/8-inch matched-pine (or other wood) ceiling, face-side down, over which is to be placed the common sheathing.

The outer edge of cornice is to be finished with (1 by 4-inch) crown-mold and (1 1/8 by 4 1/2-inch) fascia.

Gutters on Roof. The gutters on the roof are to be formed with (7/8 by 4-inch) cypress strips set on edge and nailed to the roof over the shingles, and (1 3/4 by 3 by 5-inch) sawed pine (cypress, cedar) brackets are to be put

up, set (30 inches) apart. The gutters are to have a fall to outlets equal to 1 inch in 20 feet. The eaves of the dormers are to be finished in the same manner as the eaves of the house, but with (3 by 6-inch) rafter-ends and without gutters.

Box Cornices. The cornices on the ell of the house are to be formed with (1 by 4-inch) crown-mold, (⅞ by 4½-inch) fascia, (⅞ by 10-inch) planceer, 8-inch frieze and (1 by 2-inch) sprung bed-mold.

[Dentils, carved moldings, brackets, frieze-ornaments, etc., if any, are to be described here.]

Cornices with Wooden Gutters (Fig. 241). The eaves are to be finished with rafter-ends dressed and sawed to a pattern, as shown on detail-drawings; and with a ⅞ by 8-inch molded frieze against the wall, with ⅞-inch boards cut between the rafters, gained ¼ of an inch into them, and driven down against the frieze to make a tight joint. The overhang is to be covered with ⅞ by 4-inch matched and beaded ceiling, face side down, over which is to be placed the common sheathing.

The edge of eaves is to be finished with a 4 by 6-inch cypress gutter, a 1⅛ by 4-inch fascia underneath, and a ¼-inch cove-molding as shown on section-drawing, the back of the gutter being left open. The gutter is to be in as long lengths as practicable, and when pieced, it is to be lined with sheet lead, 3 inches on each side of the joint.

Raking Cornices. The raking cornices are to be formed with (crown-mold, stuck to intersect with the crown-mold on the eaves) 4½-inch fascia, ⅞ by 10-inch planceer, 10-inch molded frieze and 2½ by ⅞-inch sprung bed-mold (dentils, brackets, etc.).

Verge-Boards. The gable-ends are to be finished with 1⅛ by 10-inch verge-boards, paneled as shown on drawings, by planting on, ¾ by 2-inch strips, and with (turned rosettes in the small panels). A 1 by 4-inch crown-mold is to be used for finishing above the verge-board. The verge-boards are to set 12 inches from the wall and are to be supported by 2 by 4-inch lookouts, 2 feet apart. The soffit is to be covered with 3 by ⅞-inch matched and beaded, pine ceiling, with 6-inch boards against the wall and 2 by ⅞-inch bed-molds.

Brackets are to be placed back of the verge-boards, at the corners of the building, to stop the gable-finish; and are to be 4 inches thick, with molded edge and (paneled) sides, as per detail drawings.

Belts. The belts at the base of front gable and at second-floor level are to be formed by putting on furrings over each stud on top of the sheathing (boarding) and placing a second boarding outside, brought to a feather-edge at the top. The under part of the projection is to be finished with ⅞ by 6-inch boards over the siding and with 1 by 7-inch sprung moldings (or brackets, dentils, etc., according to the character of the finish).

[Any other belts there may be on the house are to be described here.]

Base and Water-Table. The sides of house next to piazza and porch are to have a (1⅜ by 6-inch) base rebated on top and finished with a small bevel. The base is to stop against the piazza-posts.

Elsewhere, a water-table is to be formed just above the underpinning,

as shown in the scale detail (Fig. 288). The top piece is to have a feather-edge and the clapboards are to come down over it. (Long strips of zinc, 3 inches wide, nailed to the sheathing, are to be used for flashing behind the clapboarding and 1¼-inch on the water-table.) (See, Art. 185.)

Corner-Boards. (1⅛ by 4-inch) corner-boards are to be put on all external angles and (1⅛ by 3-inch) single strips at internal angles, where the wall is covered with siding (or clapboards). (See Art. 186.)

Other outside Finish. [Any special outside finish, such as pilasters, architraves, etc., are to be specified here.]

Carving. All carved work shown in the drawings is to be furnished and put up by the contractor, and is to be executed by a skilled carver in strict accordance with the detail-drawings and from the best quality of white pine (whitewood, also called poplar, or cypress).

(All carved panels or ornaments are to be worked from the solid and not planted on. Before any carving is done the contractor is to submit a full-size clay or plaster model to the architect for approval.)

Composition-Work. The ornamental composition-work is to be furnished and put up where indicated on the drawings. The work is to be executed by a skilled modeler in strict accordance with the detail drawings and put up in the best manner.

Scuttle. The scuttle (2 feet by 2 feet 6 inches) is to be made in roof where directed. It is to have a plank-frame, 6 inches high, and a cover made of ⅞-inch flooring and 1⅛ by 3-inch cleats, with a ⅞ by 2-inch strip around the edges. The cover is to be hung with heavy strap-hinges and is to have iron-bar fastenings, and fixtures to keep it open at any desired angle. Frame and cover are to be tinned by the tinner. (See Art. 200.)

(If the scuttle is in a deck-roof the specifications should call for permanent steps or ladder, from the attic-floor; or if the space below is finished, for a portable ladder, to be left on the premises.)

Skylight. [If there is a wooden skylight on the roof it should be specified here. See Art. 199.]

494. **Shingle Roofing.*** All roofs, except those marked to be tinned, are to be covered with one layer of water-proof paper, with 2-inch lap, and best quality of sawed cedar (cypress, white pine, redwood) shingles, laid 4½ inches to the weather (see Art. 202), and nailed with two (galvanized) nails to each shingle.

(All shingles are to be dipped (8 inches) in pure, boiled, linseed-oil (——— stain, No. ———) by the (painter) before laying.)

The hips are to be finished by laying a course of (4-inch) shingles parallel with the hips on each side, over the other shingles, and each shingle lapping the other alternately in the course. The shingles are to be laid to a straight-edge so that the angle will be perfectly straight.

[For other methods of forming hips, see Art. 203.]

The ridge is to be finished with 6 by ⅞-inch saddle-boards, tongued and

* Much valuable data for the revision of this article and of those following on flashing and tinwork, was furnished by the N. & G. Taylor Company, Philadelphia, Pa.

grooved together (or, the ridges are to be covered by a galvanized-iron cresting, as specified elsewhere).

495. **Flashing and Tinning.** All Flashing is to be of ——— tin, painted both sides before laid, IX for the valleys and gutters and IC elsewhere (or 16-ounce copper); all is to be furnished and painted by the tinner, and put on by him, with the exception of the tin shingles, which are to be worked in with the shingles by the carpenter.

[All tinwork, including flashings, should be done by a competent sheet-metal worker. In many localities the carpenter puts on all the flashing, buys the tin and cuts it up himself; but this is considered bad practice as the carpenter is seldom posted as to the various qualities of good tin.]

Valleys (*open*). The main valleys are to be lined with strips of tin, 20 inches wide, with end-joints locked and soldered. The valleys formed by dormer-roofs are to be lined with tin 14 inches wide.

(*Close valleys*, see Art. 205, should be specified as follows: The valleys are to be formed by working pieces of tin, 9 by 14 inches in size, in each course of shingles.)

The chimneys, sides of dormers, where the porch-roof joins the wall, and all rising-parts, are to be flashed against with tin, cut to turn up (3½ inches) on the wall or chimney and 3 inches on the roof. Where tin "shingles" are used they are to be not less than 7 by 6⅝ inches in size.

The crickets behind the chimneys are to be covered with tin, turned up 4 inches on the roof and 3 inches against the chimney.

A wide, tin apron is to be furnished to go under the dormer-window sills, and to be carried up and nailed on the inside.

Counterflashing. All flashing against brickwork or stonework is to be counterflashed with 4-pound lead, wedged (built) into the joints of the masonry at least 1 inch, with lead wedges, and turned down over the flashing to within 1 inch of the roof. Elastic cement is to be used for pointing above the flashing.

The curb and cover of scuttle are to be tinned to make a tight job.

Any and all other flashing necessary to make the roof tight and to stop all leaks caused by workmen, is to be done.

496. **Tin and Galvanized-Iron Work.** *Piazza-Roof.* The piazza-roof is to be covered with ——— tin, sheets 14 by 20 inches in size. The tin is to be laid over one thickness of dry felt, with joints locked and soldered in the best manner and secured to the roof by three tin cleats to each sheet; rosin only, is to be used as a flux for soldering. The tin is to be carried up 4 inches on the sheathing under the siding (or shingles) and over the edge of the crown-mold of cornice, and is to be secured with galvanized-wire nails.

The tin is to be turned up 4 inches around all balcony-posts, and soldered at the angles, and the roof is to be made tight in every place.

Gutters. The gutters are to be lined on the roof with IX tin (20) inches wide, with end-joints locked and soldered. The tin is to be turned over the edge of the standing strip and secured every (4 inches) with galvanized-wire nails.

Hanging Gutters. A 5-inch half-round galvanized-iron gutter is to be

put under eaves of rear porch, supported every 3 feet by —— hangers screwed to the fascia and adjusted to give a fall of (1 inch) to the gutter.

Conductors. (Five) galvanized-iron conductors from gutters on main roof are to be furnished and put up where shown on elevation-drawings, two from the ell, two from the front porch and one from the rear porch.

Those from the main roof are to be corrugated, 3⅛ by 4¾ inches in size, with ornamental heads, and made according to elevation and detail-drawings. Those from the ell-roof are to be of (3½)-inch and those from porch and piazza 2½-inch round pipe, without heads.

All are to be secured to the wall, by galvanized-iron hooks, or clamps, so that they will stand clear from all moldings, and are to be properly connected with the gutters. Conductors are to terminate with (3-inch) offsets, 6 inches above grade (or are to be connected with drain). The openings in the gutters are to be covered with galvanized-wire baskets. The tinner is also to furnish (and put on) the flashing specified above.

Painting. The painting of all tinwork is to be done by the roofer, with red-lead, red-oxide, metallic-brown, or Venetian-red paint, and pure linseed-oil; no patent dryer or turpentine is to be used. Paint is to be applied with a hand-brush and is to be well rubbed on. Exposed surfaces of the tin are to be painted immediately after laying. A second coat is to be applied in a similar manner two weeks later. All tin for roofs is to be painted on the under side, and all tin flashing of valleys, gutters, etc., is to be painted on both sides by the tinner before it is put up, with red-oxide, metallic-brown, Venetian-red, or red-lead and linseed-oil paint.

Guarantee. The sheet-metal worker is to give the owner a written guarantee to keep all roofs and gutters water-tight for (one) year from date of completion, free of charge.

[For wooden conductors and lead goose-necks, see Arts. 177 and 179.]

497. Wall and Gable-Shingling. The walls of second story, and all gables, walls of dormers, etc., are to be covered with the best quality of sawed cedar (cypress, white pine or redwood) shingles, in widths of from 4 to 8 inches (or in 6-inch widths), laid 5 inches to the weather and nailed with two common nails to each shingle. Where shingles come against a door or window-casing, they are to be nailed only at the side next the casing. Under window-sills and elsewhere, where exposed, the nails are to be galvanized.

Shingles in gables are to be laid alternately long and short, but not selected for uniform width, the difference in length being made (1¼) inches.

Cut Shingles. Cut shingles of uniform width and of pattern shown are to be used where shown on elevation-drawings.

[Wall-shingles may be laid as much as 6 or 6½ inches to the weather, the latter being for 18-inch shingles.]

498. Siding. All other portions of the walls are to be covered with clear, white pine (Douglas fir, cedar, spruce, redwood, cypress) lap-siding, 6 inches wide, laid 4½ inches to the weather and well nailed over every bearing with sixpenny nails set in for puttying.

No butt-joints are to be allowed in panels 12 inches and less in length, and

none is to come over a window-opening in the first course above such opening.

[In place of lap-siding (beveled-siding), the drop-siding or novelty-siding, molded as per detail drawings, may be specified.]

Clapboards. [Used instead of siding in some localities.]

All other parts of the wall are to be covered with sap-extra pine (clear spruce, cypress, cedar, Douglas fir, larch, redwood) clapboards, all laid to a perfectly even gauge of not over 4½ inches, and nailed to every stud with sixpenny (galvanized) nails, set in for puttying. (For butt-joints, see above.)

Sheathing-Paper. The sheathing under all siding (or clapboards) is to be covered with one thickness of (——— medium-weight, asbestos sheathing-felt) laid with a lap of not less than 2 inches. The same kind of felt is to be used for lining under all corner-boards, casings, etc.

Zinc. Strips of zinc 3 inches wide are to be put around all window and door-casings throughout, turned up ¾ of an inch against casings and laid under the clapboards.

[Tin shingles (2 by 7-inch) are sometimes laid in with the shingles against the casings.]

499. Piazza. The front piazza is to be finished as shown on the elevation and detail-drawings (see Fig. 295, detail *B*).

The floor is to be laid with (1⁵⁄₃₂ by 3¼-inch) matched (long-leaf) pine (white pine, Douglas fir), flooring, tightly strained in place, blind-nailed to every bearing with eightpenny nails, and jointed in white lead. The outside edges of the floor are to be finished with a rounded nosing and a ¾ by 1-inch cove below it. Casings of ⅞-inch pine (cedar, cypress, Douglas fir), ⅝ of an inch thick and (8 inches) wide are to be used for finishing under the edges. The piers are to be cased with (12-inch) pine (cedar, cypress, Douglas fir), boards with beveled bases. The spaces between the piers are to be filled with lattice-work formed of ¾ by 2¼-inch strips halved together, with spaces 2½ inches square, and with frames of ⅞-inch pine (cedar, cypress, Douglas fir), boards, 4 inches wide. (Each panel of lattice-work is to be put together in one piece, so that it may be removed if desired.)

The columns are to be turned from 10 by 10-inch whitewood (called, also, poplar) (redwood, cedar or cypress) and extended inside of the pedestals to the floor. The column-caps are each to be made from a separate piece of wood, and carved as per full-size details. The column-bases are each to be turned in two pieces, and fitted around the columns, the congès and fillets being turned on the column shaft. The flutings are to diminish in cross-section size, leaving the fillets between them the same width throughout their length. The pedestals are to be formed about the columns with 1⅛-inch pine (cedar, cypress, Douglas fir) frames, plain panels and ½ by ¾-inch panel-molds, with ⅞-inch beveled bases, mitered at the angles. The pedestal cap is to correspond in profile with that of top rail of lower balustrade.

Half-pilasters are to be put against the walls, fluted to correspond with columns and with bases and pedestals to correspond.

The architrave and cornice are to be formed with wide, pine (cedar, cypress, Douglas fir), casings, 1⅛ by 2¼-inch band-molds inside and outside,

and ⅞ by 2½-inch bed-molds; ⅞ by 4-inch crown-molds, 4-inch fascias and 8-inch planceers.

Furring for level ceiling is to be placed under the rafters and covered with ¾ by 4-inch (center-beaded) clear, pine ceiling, with bed-molds the same as under the cornice.

The railings are to be constructed with top rails built up and molded, and bottom rails stuck from 2¾ by 3½-inch stock, with upper edge beveled.

Top rails are to be ramped and are to miter with caps of pedestals and columns. Balusters are to be 1⅝-inch, turned and set 3½ inches on centers.

The columns of upper balustrade are to be turned from 5 by 5-inch whitewood, called also poplar, (cedar, cypress), with turned ornaments on top. Cap-moldings are to correspond with rails.

The posts or pedestals of the upper balustrade are to be set on 1⅜-inch pine (cypress, cedar, Douglas fir), blocks, 6 inches square, nailed over the tin roofing and covered with tin soldered to the roof. The center post is to be secured by an iron brace. Half-posts are to be put against the wall to receive the balustrade.

The steps are to be constructed on 2 by 10-inch plank carriages, 16 inches on centers and resting on a 4 by 6-inch sleeper at the bottom. (A flat stone is better.) Treads are to be 1¼ inches thick with rounded nosing and cove, returned at the ends. Risers are to be ⅞ of an inch thick. The ends of steps are to be finished with ⅞-inch pine (cypress, cedar, Douglas fir), strings and casings, with panels formed of ¾ by 4-inch center-beaded pine ceiling.

500. Rear Porch. The floor of rear porch is to be laid with ⅞ by 4-inch clear (hard pine, Douglas fir), boards, dressed on one side, finished with square edges, and laid ⅛ of an inch apart. The edges of the floor are to be finished with a rounded nosing and a ¾ by 1-inch cove-molding. Casings of 10-inch pine (cedar, cypress, Douglas fir), are to be used for finishing below the edges of floor. The piers (or posts) below the floor are to be cased with wide pine (cedar, cypress, Douglas fir) boards; and to fill in between them, ⅞ by 6-inch pine (cedar, cypress, Douglas fir) boards cut to pattern, as shown, and a ⅞ by 8-inch beveled base, are to be used. The porch columns are to be 5 inches square, built up of pine (cedar, cypress, redwood, Douglas fir) boards carefully fitted together. The cornice is to be finished with a ⅞ by 4-inch crown-mold, fascia and planceer, as shown. The gable-ends are to be filled in with ⅞ by 4-inch, double-faced, pine ceiling. All the openings between the columns and over the door are to be filled in with diagonal, lattice-work, made of strips ¼ by 1⅛ inches in section and set 1⅛ inches apart.

Center-beaded pine ceiling (¾ by 4-inch), with a ⅞-inch quarter-round mold broken around the edges, is to be used for ceiling on the bottom of rafters.

The steps are to be built on 2 by 10-inch plank carriages, 16 inches on centers, resting on a 4 by 6-inch sleeper at the bottom. Treads are to be 1⅛ inches thick, with molded nosing returned at the ends; and risers are to be ⅞-inch thick, all of white pine (long-leaf pine, Douglas fir).

Boards cut to pattern, as under the porch, and with a beveled base, are to be used for filling under the ends of steps.

501. Cellar Hatchway or Bulkhead. The bulkhead-entrance to cellar is to be made with plank steps on plank carriages, set 16 inches on centers; all to be planed; no risers.

The brick (or stone) walls are to be covered with a strong, plank frame bolted to the brickwork on each side by two ¾-inch bolts, 20 inches long. The frame is to be covered with white pine (cypress, cedar, redwood, Douglas fir), boards with 6-inch casings on the sides. Double doors are to be constructed of 1 by 4-inch matched-pine (cedar, cypress, Douglas fir) boards, secured with 1⅛ by 6-inch beveled cross-pieces screwed on the under side. The meeting-joint is to be battened and the bulkhead rendered water-tight. A water-way is to be formed at the top, and the edges of the frame next the doors are to be covered with tin and grooved to catch the water entering at the joints. (See Art. 165.)

The doors are to be hung with 8-inch, heavy, strap-hinges bolted to the door and screwed to the frame, and provided with a pivoted, hardwood bar-fastening.

[A single door may be secured by a hook and staples.]

502. Windows. All window-frames are to be made in accordance with the scale and detail-drawings. All are to be made of clear, white pine, (whitewood, also called poplar, cypress, larch, Douglas fir, western white pine), except pulley-stiles and parting-strips, which are to be of clear, long-leaf pine.

Cellar Windows. All windows in cellar or basement are to have 1¾-inch rebated frames and sills with 1¾-inch molded, staff-beads. The frames are to be rebated on the outer edge for screens. The frames on sides and rear are to have ¾-inch round-iron, vertical bars, from 3 to 4 inches on centers, let into head and sill. Frames are to be fitted with 1⅜-inch white pine (cypress, whitewood, also called poplar, larch, western white pine, Douglas fir) sashes, divided into lights as shown and glazed with first-quality single-thick glass. The sashes are to be hinged at the top, fitted with hooks and staples to keep them open, and strong japanned-iron button fastenings (bolts or slip-latches).

The frame for cold-air opening is to be covered with heavy ⅜-inch-mesh galvanized-wire netting, nailed securely on outside of frame.

Grilles. Ornamental wrought-iron grilles, made in the best manner in accordance with the detail drawings, are to be furnished and fixed in the front cellar-window frames (with No. 14 screws).

Casement-Windows. All frames for casement, French and stationary windows are to have 1¾-inch rebated jambs and 1¾-inch sills, ploughed as per full-size sections. The outer edge of frame is to set flush with the sheathing and is to have 1⅛ by 5½-inch casings and ¾ by 2½-inch band-molds.

The sash in small window in coat-closet is to be screwed in tight; the others are to be hung at the sides to swing in.

Double-hung Windows. All other windows throughout the house are to have frames made for double-hung sash, with ⅞-inch long-leaf pine pulley-stiles, ⅞ by ½-inch parting-strips, ¾-inch ground-casings, 1⅜-inch yokes and 1¾-inch sills. The sills are to pitch 1 inch and to be ploughed for shingles or clapboards as required.

The pulley-stiles are to be tongued into the outside casings and fitted with pockets to give access to the weights. The windows are to be cased on the outside (over the sheathing) with 1⅛ by 5½-inch white pine (white cedar, Douglas fir, larch, redwood, cypress) casings, with ¾ by 2½-inch band-molds, planted on. The windows in first story are to have 10-inch frieze-boards above the band-molds, with molded cornices with one row of dentils, as per full-size details. Strips of tin (zinc) 3 inches wide are to be used for flashing over the tops of all casings.

All frames for double-hung sashes are to have ⅜-inch wood pendulums between the weights, hung from the yokes.

Box Heads. The frames in (specify where) are to have box heads with the pulley-stiles extending to the top. The sashes are to slide into the heads and are to have followers.

Sashes. All sashes above the cellar are to be made from special designs, of clear well-seasoned white pine (cypress, whitewood, also called poplar, western white pine, larch, Douglas fir), glued and wedged in the best manner, and divided into lights, as shown on the drawings. All sashes in first and second-story windows of main part of house are to be 1¾ inches thick. All others are to be 1⅜ (1½) inches thick.

The sashes for French windows are to have astragal-moldings on the meeting-stiles and beads on the jamb-stiles to fit into the jambs, as per full-size sections; bottom rail is to be 5½ inches wide.

Paneled Doors Below Sash. The windows opening onto the front balcony are to have two paneled doors below the lower sash, with a rebated joint in the center and with a tongue on the top. The lower sash is to be grooved to fit over the tongue and both sashes are to slide up into a box head.

Storm-Sashes. Outside sashes are to be provided for all exterior windows on the north and west sides of the house, and to be made of clear, well-seasoned white pine (cypress, whitewood, also called poplar, larch, western white pine, Douglas fir), divided into four lights packed with listing around the edges and secured to the frames on the inside with (——— storm-sash buttons, coppered finish) four to a window.

All storm-sashes are to be glazed with first-quality double-thick glass, and are to be fitted, marked by the contractor and stored where directed.

Priming. All sashes are to be primed on both sides by the contractor before they are brought to the building. Sashes for rooms which are to have a natural-wood finish are to be primed on the inside with pure, boiled, linseed-oil.

503. **Glass.** The large lights of the middle front window are to be glazed with polished American-plate glass, back-puttied and secured by wooden beads.

All other windows in the first and second stories of the main part of the house (except those marked "leaded glass") are to be glazed with (——— double-thick glass) (——— 26-ounce crystal-sheet glass) (first-quality AA double-thick, American or German glass).

All other sashes are to be glazed with first quality (AA) single-thick glass. All glass is to be well-bedded, tacked and puttied.

Leaded Glass. (See Art. 154.)

504. Outside Blinds. Outside blinds for (all) windows above the basement are to be provided and hung; to be made of first-quality white pine (whitewood, also called poplar, larch, western white pine, Douglas fir), 1⅛ inches thick and with rolling slats (in the lower half only). Blinds for all windows 4 feet wide and over are to be divided into four folds; all others are to be in two folds.

All four-fold blinds are to be hung with wrought-iron hinges and fastened with gravity-lock blind-fasts. Blinds in two folds are to be hung with ——— gravity blind-hinges and fitted with ——— wire, blind-fasts.

[For blind-hinges and fasts, see Arts. 436 to 438.]

All blinds are to be marked and a corresponding mark is to be put on the frames.

505. Outside-Door Frames. All outside-door frames are to be made from clear, short-leaf pine (Douglas fir, spruce, Norway pine, hemlock) stock 1¾ inches thick, rebated and beaded on the inner edges, and furnished with 1¾-inch molded, long-leaf-pine (white oak, maple, Douglas fir), thresholds. All are to be set plumb and square.

The frames are to be cased on the outside, over the sheathing, with 1⅜ by 5½-inch white pine (cedar, cypress, redwood, Douglas fir) casings, backbands, cornices, etc., to correspond with the windows. The front entrance is to have side lights and transom, fluted mullions with cap and base, and molded transom-bar with dentils. Side-lights and transom-sash are to be (stationary) 1⅜ inches thick, divided into lights as shown, and glazed with 26-ounce crystal-sheet glass.

For finish under the side-lights, 1⅜-inch sills and panel-work, inside and outside are to be used. The frames and sashes are to be veneered on the inside with kiln-dried, quarter-sawed, white oak (any of the hardwoods, cypress, redwood, Douglas fir), and the panels are to be of oak (any of the hardwoods, etc.).

All are to be worked and put together in the best manner, and in strict accordance with the detail drawings. The (white oak) veneering of frames is to be filled and shellaced by the carpenter before it is brought to the building.

506. Preparation for Tiling. The floor of bath-room is to be prepared for tiling, by nailing ⅞-inch boards to cleats nailed to the sides of the joists. The tops of the boards are to be (5 inches) below the top of the flooring. The joists are to be beveled on both sides to an edge on the top.

The side walls are to be prepared for tiling by nailing 2 by 3-inch pieces horizontally between the studs, about 12 inches apart, to a height of 4 feet (for metal-lathing). (See Art. 214, Chap. V, for a more detailed description.)

507. Underflooring. An underfloor is to be laid throughout the first and second stories of good hemlock (spruce, native pine) boards, surfaced on one side and nailed to every bearing with two eightpenny nails.

The boards are to be laid diagonally on the beams in the first story of the main part of the house, and at right-angles elsewhere. All end-joints are to be cut over a beam in every case, and suitable nailing-pieces are to be cut

between the joists at the side walls for the diagonal flooring. The flooring is to fit closely around all studs and out to the outside sheathing.

A single floor is to be laid in the finished parts of attic of (4-inch) clear, spruce (native pine) flooring, matched and blind-nailed, and tightly strained, with heading-joints cut over bearings in all cases.

All ridges due to an uneven thickness of the boards are to be smoothed off as soon as the flooring is laid.

508. Grounds and Furring. Grounds are to be put on for ⅞-inch (¾-inch) plastering around all door and window-openings, and for bases, wainscoting, wood cornices, etc., as directed; two lines of grounds are to be placed behind the base.

Wood corner-beads, ⅞ of an inch in section, are to be put up on all projecting corners, stuck as per marginal sketch (Fig. 346, detail *B*), or, steel corner-beads are to be put on all projecting angles, set true and plumb and well secured.

All ceilings, including basement-ceiling, are to be cross-furred with 1 by 2-inch strips, set 12 inches (16 inches) on centers. Rafters in finished attic-rooms are to be cross-furred diagonally with strips 12 inches on centers; attic outside-walls are to be furred out with studding to give a (4-foot) vertical height, and attic-ceiling is to be furred down to give a (9-foot) clear height.

Arches, cornices, ceiling-beams, etc., are to be furred as required by the scale drawings and full-size sections.

Furring is to be put on for the plaster-coves in the parlor and front chamber, with brackets cut out of 1¼-inch boards, and set 16 inches on centers.

All chimney-breasts are to be furred with 2 by 4-inch studs, set flatwise, 1 inch clear of the brickwork and 16 inches on centers.

The outside stone walls of (laundry) are to be furred with 2 by 4-inch studs, set flatwise, 16 inches on centers.

All furrings, grounds and angle-beads are to be strong, true and plumb.

509. Partitions. All partitions are to be set as shown by the yellow color on the plans, with 2 by 4-inch (spruce, Douglas fir, Norway pine, short-leaf pine, hemlock) studs, sized to a uniform width, set 12 inches on centers for bearing-partitions, and 16 inches for all other partitions; all to be straight and plumb. They are to be tested with a straight-edge, and straightened and bridged before plastering.

All partitions except those that stand over each other are to stand on a 2 by 5½-inch sole-piece, and all are to have (3 by 4-inch) (short-leaf pine, Douglas fir, Norway pine) caps. Where a partition stands over another or over a wall or girder, the studs of the upper partition are to stand on the cap of the partition below or on the girder, and not on the flooring nor on the joists. All openings in partitions which extend through more than one story or carry joists, are to be trussed over with double headers, 1-inch apart; and all partitions not supported from below are to be strongly trussed so as to have the weight taken off the middle of the joists.

All corners and angles are to be formed solid so that there can be no lathing through angles from one room to another. All round corners are to be furred for horizontal or diagonal lathing.

A 2-inch plank header is to be cut between the studs over the pocket for sliding-door partitions, (8 inches) above the soffit of the doors; and the pockets below are to be lined with ⅝ by 6-inch matched boards (painted on both sides before they are put up).

All partitions in first and second stories are to be bridged with (two) rows of horizontal (diagonal) bridging of 2 by 4-inch pieces cut in between the studs and nailed with two tenpenny nails at each end of each piece.

Mineral-Wool Filling. Mineral wool is to be used for filling in between studs at (south and east) sides of bath-room, from floor to ceiling.

Mice-Stops. Strips of tin, bent to form a right angle, are to be furnished and put down between the studs of all outside walls on each floor. This tin is to be well nailed to the floor and the sheathing to prevent the circulation of mice. All holes around the studs at partitions are to be closed in the same way.

510. **Cutting and Fitting.** All cutting and fitting required by plumbers, gas-fitters or steam-fitters, and for furnace-pipes and registers, is to be done, and repairs neatly made afterwards. No bearing-timbers are to be cut without consulting the architect.

511. **Temporary Enclosing.** The contractor is to temporarily enclose the building as soon as it is ready for lathing, furnishing and hanging temporary doors with locks and covering the windows with muslin, boards or temporary, glazed sashes. At least one-half of the total number of openings are to be closed with muslin.

No permanent sash is to be set in the windows (except in the unfinished part of the attic) until the plaster is dry.

The foregoing specification is intended to cover all work required to complete the building on the outside ready for the painter, and to prepare it on the inside for the lather, with the exception of the rough work for the stairs. Occasionally this much of the work is let by itself, the finishing of the building being let under another contract.

3. CARPENTERS' WORK. BRICK BUILDINGS.

512. **General Provisions.** Specifications for the carpenters' work of a brick dwelling, with steep roof in front and flat roof in the rear, both stopped by fire-walls at the sides; copper cornice; copper bay window in second story; and brick, stone and tiled front porch, without roof. Specifications are to be preceded by the general conditions.

513. **Privy.** A temporary privy is to be built in the rear part of the lot as soon as building operations are commenced, removed on the completion of the work (cleaned out) and filled up with earth, neatly leveled off.

514. **Timber.** [This may be specified as in Art. 490. If the sizes are not all shown on the drawings they should be given in the specifications.]

515. **Framing.** The floors, roofs, ceilings and partitions are to be

framed in a substantial manner as shown on drawings and as herein described: all joist-hangers, steel beams, bearing-plates, bolts, nuts and washers, indicated on the drawings and herein specified are to be furnished by the contractor.

The carpenter is to exercise care in framing so that important timbers will not require cutting for furnace-pipes, gas-pipes, etc.

All framing is to be kept 2 inches from the outside of the chimneys, and in no case is any timber to be allowed to rest on the chimneys.

Floor-Framing. The laundry is to have a wooden floor formed of 2 by 8-inch joists, 16 inches on centers, resting on a dwarf wall in the center and on ledges built in the foundation walls at the sides. All other parts of basement, except coal-bins, are to have cement floors.

Girders and Posts. The dining-room floor-joists are to be supported by an 8 by 10-inch long-leaf pine (Douglas fir) girder in one length, supported at the ends by the brick partition-walls and resting at the ends on 8 by 12 by 1-inch cast-iron bearing-plates or wall-hangers. The center of the girder is to be supported by an 8 by 8-inch wooden post, dressed on four sides, and chamfered at each corner. The post is to rest on a 12 by 12 by 1¼-inch cast-iron plate furnished with a dowel in the center and bedded on a stone pier, or it is to rest in a steel post-base.

All other first-floor joists are to be supported by the partition walls. Long 2 by 10-inch long-leaf pine (Douglas fir) planks are to be furnished and are to be bedded in mortar on the walls and leveled carefully by the brick-mason.

The ends of all floor-joists are to rest on wall-hangers or are to be built into the brick walls; in the latter case they are to be beveled 3 inches. All floor-joists are to be crowned ¼ of an inch for every 12 feet of span. Where the ceilings are not furred the joists are to be made concave on the under side but kept a uniform width.

All floor-joists are to be carefully leveled at their ends, and on the brick walls are to be wedged up with hard brick or slate chips; no bond-timbers are to be built into the walls.

Dining-room joists are to be framed flush with girder and supported in ——— joist-hangers.

The first-floor joists are to be framed around all basement-windows with double headers and trimmers hung in joist-hangers. Tail-joists are to be mortised 1 inch into headers and well spiked.

The floor-joists, ceiling-joists and rafters are to be framed around all chimneys, hearths, scuttles, skylights and stair-openings with double headers and trimmers, framed as above, except that all headers over 4 feet long are to be hung in ——— joist-hangers.

The trimmers for front-stair well in second story are to be 6 by 12-inch long-leaf pine (Douglas fir) beams, extending from wall to partition, and the header is to be a 10-inch, 25-pound, steel beam with two 3 by 10-inch planks fitted between the flanges and bolted to each side with ¾-inch bolts, spaced 2 feet apart in the length of the beam and staggered. The header is to be hung in a hanger (⅜ by 3½-inch stirrup) at each end. Tail-joists are to be framed into the 3 by 10-inch plank (or hung in hangers) and every third

joist is to be tied to the header by a ½-inch round-iron dog, hooked over the I beam and let into top of the joist.

The bay window in the second story is to be framed by bolting a 2 by 10-inch plate to the bottom of the opening, framing 2 by 12-inch floor-joists, 8 feet long, on top of it, extending these joists 4 feet inside of the wall and securely spiking their inner ends to another 3 by 12-inch floor-joist. The two outer joists are to be 4 inches thick, with the common joists framed into them. Pieces (2 by 4-inch) are to be cut between the bay-window joists, on a line with the other joists to receive the flooring.

The floor-joists are to be doubled under all partitions running the same way, spaced 4 inches apart, and blocked every 2 feet with 4-inch lengths of 2 by 12-inch pieces securely spiked to each joist.

Bridging. [All floor-joists should be bridged once in every 8 feet in length, as specified in Art. 491.]

Ceiling. The ceiling over third story is to be framed in the same way that the floors are framed (omitting the bridging), the joists resting on the walls and on the partition-caps. The ceiling-joists are to be trussed from the rafters of the flat roof, as shown on section-drawings, with 1 by 6-inch boards, nailed to every joist and rafter with tenpenny nails. Temporary supports are to be put under the ceiling-joists, 6 feet from the bearing-walls, until the joists are trussed.

Roof-Framing. A 4 by 10-inch plate, in two thicknesses, breaking joint, is to be bolted on top of the front wall, with ⅞-inch bolts, 30 inches long, built into the brickwork by the mason, and spaced not over 6 feet apart.

The pitched roof is to be framed in front with 2 by 8-inch rafters, spiked to the wall-plates, and with a 2 by 14-inch long-leaf pine (Douglas fir) ridge, put up in one length. Dormer-openings are to be framed with a 4 by 8-inch rafter on each side, and a 4 by 10-inch header above the opening, 8 feet above the third-story floor.

The flat roof is to be framed with 2 by 8-inch joists, built into the fire-walls, and the partitions running lengthwise of the building are to be carried up to support these joists at their inner bearings. Rafters are to be trussed from ceiling-joists as above specified. Scuttle and skylight-openings are to be framed as if they were in the floors.

A 2 by 10-inch plate is to be bolted on top of rear wall, with ¾-inch bolts, 24 inches long and not over 6 feet apart, with its upper surface flush with the top of the roof-joists.

Dormers. Dormers are to be framed with 2 by 4-inch studs, 4 by 4-inch corner-posts, 4 by 4-inch plates, double and breaking joints, and 2 by 6-inch rafters, 16 inches on centers. The studs at sides of dormers are to be notched 1 inch over the rafters, extended to the floor and securely spiked.

516. Beam-Anchors. The floors, ceiling-joists and rafters of the flat roof are to be tied to the side walls, every (6) feet by iron anchors, formed of ¼ by 2-inch irons, 20 inches long, with 3 by 3 by ¼-inch plates, riveted to the wall-ends (or turned up 4 inches in the wall). Each anchor is to extend into the wall 8 inches and is to be spiked to the side of the joist, near the bottom, by three twentypenny spikes, driven through the joist and

clinched. The ends of the main ridge are to be tied to the side walls in the same way.

The front and rear walls are to be tied to the floor-joists every 6 feet by cutting pieces of 2 by 4-inch material between the joists and spiking the anchors on top. The fire-walls at the sides of the pitched roof are to be tied to the rafters twice on each side in the same way.

[The most effective anchors are those that pass entirely through a wall, with a plate, head or nut and washer on the outside; but such anchors can be used only where the appearance of the wall is of no consequence. Where such anchors are considered necessary on a finished wall, ornamental heads may be used.]

517. Partitions. [These may be specified as in Art. 509.]

518. Lintels, Arches, Wood Bricks, Etc. Arched, wooden lintels, 5 inches high at the center and 1½ inches high at the ends, are to be put over all openings in brick walls; and are to rest not more than 1 inch on the brickwork.

The opening for bay window in front wall is to be spanned by two 10-inch 25-pound steel beams, bolted together with three cast-iron separators and ¾-inch bolts, so that the lintel will be 11 inches wide, outside to outside of flanges. The beams are to have a bearing of 6 inches at the ends, are to rest on 8 by 12 by 1¼-inch cast-iron plates, and are to have an anchor 16 inches long at each end. A 2 by 8-inch plank is to be bolted to each side of the web of the lintel.

[If any other special lintels are required, they should be specified here.]

All forms for brick or stone arches and any templates required are to be made and set, as required, by the brick or stone-masons.

Wooden bricks (2½ inches) thick are to be furnished by the contractor for carpenters' work, and the masons are to build them into the wall wherever necessary for the proper execution of the work. (Or porous terra-cotta blocks, or some approved form of metal wall-plugs for nailings are to be furnished by the carpenter. See Art. 361, "Building Construction and Superintendence, Part I, Mason's Work," by F. E. Kidder.) A piece of 2 by 4-inch spruce is to be furnished by carpenter and built into the wall back of all window-sills by the mason.

The carpenter is to spike 3 by 4-inch joists to the ends of the rafters of flat roof, flush with inside of fire-wall, to hold the flashing.

519. Lookouts and Bond-timbers for Cornice. Lookouts of 2-inch plank for the front cornice are to be furnished, set and notched for the plates; also 3 by 4-inch bond-timbers for the molding under frieze, and 2 by 4-inch vertical pieces every 26 inches for securing the frieze. All are to be built in by the brick mason but furnished and set by carpenter.

520. Framing for Bay Windows. The bay window in second story is to be framed with 2 by 6-inch studding, 2 by 6-inch sole-pieces spiked to top of joists, 4 by 6-inch plates breaking joint, and 2 by 6-inch rafters. The outside and the roof and the under side of the floor-joists are to be sheathed with ⅞-inch native pine (hemlock) sheathing, surfaced one side

to a uniform thickness. The sides of bay and the roof are to be secured to the front wall by (six) ¾-inch bolts, 14 inches long, and with 4 by 4 by ¼-inch washers built into the wall.

521. Protecting Stonework. The carpenter is to protect all stone sills, steps, copings, jambs, carved capitals and other parts of the stonework likely to be injured, by covering them with boards properly secured and maintained until all exterior work, including the painting, is completed.

522. Sheathing and Underfloors. All roofs and sides of dormers are to be covered with native pine (spruce, or hemlock) sheathing, free from holes or large knots, surfaced one side to an even thickness and nailed to every bearing with two eightpenny nails.

A ridge-pole is to be formed on main ridge, made of two 1¼ by 6-inch boards, clinched together, set over the sheathing and spiked to it.

Underfloors. [These may be specified as in Art. 507, the boards being laid close against the walls.]

523. Scuttle and Skylight. [The scuttle may be specified as in Art. 493.]

The frame for skylight (on flat roof) is to be made of 1¾-inch white pine, (cedar, cypress) planks, 11½ inches wide, set on top of sheathing and pitching 6 inches toward the rear. The top of frame is to be grooved as per detail, and the outside is to be tinned by the tinner. The frame is to be covered with a skylight-sash 2¼ inches thick, and 2 inches wider than the frame, with a ¾-inch strip nailed to the under side to fit against the frame. The sash is to be glazed with ⅜-inch ribbed glass, each light being the full length of the sash. The sash is to be hung with heavy wrought-iron butts, and secured with bar-fastening. The sides of opening are to be ceiled from the third-story ceiling to the under side of the sash with ⅝ by 4-inch (native pine) ceiling.

A 1⅛ by 8-inch white-pine (cypress, cedar) board is to be put across the rear wall, with the top edge flush with the sheathing to receive the gutter, and a 1¼-inch quarter-round molding is to be put under the gutter.

524. Bulkhead. [Same as in Art. 501.]

525. Rear Porch. The porch-floor is to be constructed with 2 by 6-inch joists, 16 inches on centers, placed parallel with the rear wall and framed flush between 6 by 8-inch girders resting on the brick piers.

The floor is to be covered with ⅞ by 4-inch (quarter-sawed) long-leaf pine (Douglas fir) flooring, matched and blind-nailed and tightly strained. The edges of the floor are to be rounded and to have a cove underneath. Wide, white pine (cedar, cypress, Douglas fir) casings are to be used for finishing under the floor and in front of the piers, and the spaces between the piers are to be filled in with (diagonal) ¼ by 1⅛-inch lattice-work, with 1⅛-inch spaces and a 1⅛ by 7-inch, beveled base. The steps are to be built on 2 by 10-inch plank carriages, 16 inches on centers, resting at the bottom on a long stone slab. Treads are to be 1⅛ inches thick, and risers ⅞ of an inch thick, with rounded nosings returned at the ends and with a cove underneath. The strings are to be cased with ⅞-inch pine (cedar, cypress) boards, and lattice-work, the same as under the porch, with ⅞ by 5-inch frame and beveled base, is to be used for filling in to the ground.

The posts are to be formed of 4 by 4-inch straight, well-seasoned spruce (cedar, cypress), cased with ⅞-inch white pine (cedar, cypress, redwood), with angles chamfered. The rough posts are to be carried up to support a 6 by 8-inch plate. Rafters are to be 2 by 6 inches; hip-rafters 2 by 8 inches.

(Four) ¾-inch bolts (14 inches) long, with 4-inch, square, washers to bolt the porch-roof to the wall, are to be provided by the carpenter and built into the rear wall by the mason.

Furring is to be nailed to the rafters to form level ceiling, and ceiled with ¾ by 4-inch center-beaded ceiling, with ⅞-inch quarter-rounds at the edges.

Boxing is to be placed under the plate for a false beam as shown, and the cornice is to be finished with (4-inch) crown-mold, 4-inch fascia, 10-inch planceer and 2½ by ⅞-inch bed-mold. A gutter is to be formed back of crown-mold as per section, with a fall of 1 inch to the outlet.

The roof and gutter are to be covered with tin by the tinner.

The space between the posts is to be filled in with ⅞ by 4-inch double-faced white pine (cedar, cypress) ceiling (3 feet 6 inches) high, with a 2 by 4-inch rail on top. A ⅞-inch quarter-round molding is to be broken around the ceiled panels, inside and outside. The spaces above the rail and over the door are to be covered with No. 14-mesh painted wire cloth, nailed to the posts, rail and beam, and a half-round molding is to be placed over the edges (or ⅞-inch screens, mortised and tenoned together, are to be fitted in all openings above the rail and over the door, and covered with No. 14-mesh, painted, wire cloth).

The posts of the balcony-railing are to be constructed with 5 by 5-inch solid, turned, whitewood, also called poplar, (cedar, cypress, redwood) posts, extended through the roof and spiked to the plate. After the roof is tinned, a ⅞-inch beveled base is to be put on over the tin. The top rail is to be 3½ by 3½ inches double-molded, of whitewood, also called poplar, (cedar, cypress, redwood), and the lower rail 2¾ by 3½ inches, beaded on the sides and beveled on top. Balusters are to be plain, 1⅜ inches, set 4 inches on centers.

All exposed woodwork about the porch is to be of clear, well-seasoned, white pine or cypress (cedar, redwood), except where otherwise specified.

A slat-floor is to be constructed in (two) sections and laid on the tin roof. It is to be made of (1⅛ by 3-inch) long-leaf pine strips, laid ⅜ of an inch apart and nailed and clinched to 1¾ by 3-inch long-leaf pine cleats, 2 feet on centers. The floor is to be made level by blocking up on the tin roof.

526. Window-frames. All window-frames are to be made in accordance with the scale and detail drawings, and as herein specified, of clear, well-seasoned white pine (whitewood, also called poplar, cypress, Douglas fir, larch, western white pine), and are to be set in position as soon as the stone sills are set. The carpenter is to verify the measurements, to see that the sills are set in their proper position, and if any sills are set wrong, he is to see that they are changed before setting the frames. All frames are to be set plumb, kept well braced during the construction of the wall, by cross-pieces and diagonals to keep them square and to prevent the sides from springing.

Cellar-Windows. The cellar-windows are to have 2 by 12-inch white pine (whitewood, also called poplar, cypress, Douglas fir, larch, western white pine) plank frames, free from sap or large knots, rebated for sash on the inside and for 1½-inch screens on the outside; and 1¾-inch staff-beads with heads kept ⅞-inch below the furring-strips (floor-joists) and with ⅞-inch grounds nailed on top.

The sills are to have a pitch of 1 inch, and are to be formed as per full-size sections. (See Fig. 148.)

The frames on the rear and the sides of the building are to be rebated on the outer edges for 1⅛-inch screens and are to have ¾-inch round-iron bars let into the heads and sills and spaced from 3 to 4 inches on centers. The front frames are to have ornamental-iron grilles (furnished by the carpenter) as per scale and detail drawings, screwed to the inside of frames, and strips for the screens are to be nailed to the inside of the frames.

All cellar-windows are to be furnished with 1⅛-inch screens fixed with round-headed, blued screws, and covered with heavy, galvanized-wire netting on the outside and No. 14-mesh, painted, wire cloth on the inside.

All cellar-windows are to have 1¾-inch white pine (cypress, whitewood also called poplar, Douglas fir, western white pine, larch) sashes, made in the best manner, divided into lights as shown, glazed with first-quality (AA) single-thick glass, hinged at the top with japanned butts, and provided with hooks and eyes for holding open, and strong japanned button-fastenings.

Cold-Air Opening. A plank frame for cold-air opening is to be made, finished with a 1¾-inch staff-bead and covered with heavy, galvanized netting nailed to the outside of frame.

Dormer-Window Frames. The jamb, head and sill of dormer-window are to be stuck from 2½ by 10-inch pine (cypress, whitewood, also called poplar, Douglas fir, western white pine, larch) planks, molded, ploughed and rebated as per full-size section (Fig. 194); and the transom and mullion from a 3½ by 10-inch plank. The lower openings are to be filled with a single sash hinged at the sides, and the transom-sash is to be hinged at the bottom.

The back of jambs and top of head are to be flashed with strips of zinc, 3 inches wide, bent at right-angles.

Bay Windows. The bay-window frames are to be worked out of 1⅜-inch pine (cypress, whitewood, also called poplar, Douglas fir, etc.) plank, ploughed for parting-strips and blind-stops and are to have 1⅛-inch outside casings (which will be covered with copper). Sills are to be 1¾ inches thick, stuck as per details. The sashes in these frames are to be double-hung with ——— sash-balances.

Box Frames. All other windows are to have box frames for double-hung sashes (1⅛-inch) pulley-stiles and outside casings, ¾-inch box casings, ploughed for sub-jambs, 1¾-inch sills (formed as per details), (1¾-inch staff-beads), (or 1⅛ by 2-inch beaded brick-molds) and ½ by ⅞-inch parting-strips. Pulley-stiles and parting-strips are to be of clear, long-leaf pine, with pockets to give access to the weights. Three-eighths-inch pendulums are to be hung in the boxes to separate the weights. Pulley-stiles are to be ploughed into outside casings.

All frames on rear and sides are to have 1⅛-inch Dutch heads with (3-inch) rise. Frames in front elevation (where shown) are to have segment-heads inside and outside (or are to be finished square on the inside).

Box Heads. [See Art. 502.]

527. Sashes and Glass. [Same as in Arts. 502 and 503.]

Revolving Sashes: Pivoted Sashes.

528. Outside-Door Frames. The frame for front entrance is to be made with 1¾-inch paneled pine (Douglas fir, cedar, cypress) jamb, rebated and veneered with ½-inch quarter-sawed oak, (or other suitable hardwood), with 1¾-inch molded, oak staff-bead. (Transom, side lights, etc.) This frame is not to be set until the house is plastered.

All other outside-door frames are to be made from (1¾ by 8-inch) pine (cedar, cypress, Douglas fir) plank, rebated (and reeded) with 1⅛-inch beaded brick-molds; transom-bars are to be placed where shown, worked out of 2¼-inch pine (cedar, cypress, Douglas fir) plank, wide enough to stop the screen-door. Transom-sashes 1¾ inches thick, divided into lights as shown and glazed with first-quality (single)-thick glass, are to be furnished and set by carpenter. All outside-door frames are to be doweled to the stone sills by ⅜-inch iron dowels, and are to be anchored to the walls by ¼ b 2-inch iron anchors, 8 inches long, screwed to the back of the jambs, two to each jamb. Frames are to be set square and plumb and maintained so.

Priming of Outside Frames. The carpenter is to prime on all surfaces all outside-door-frames and window-frames (except front-entrance frame) before they are set, with one good coat of white-lead and linseed-oil paint. Pulley-stiles and parting-strips are to be primed with boiled linseed-oil.

[For priming of sashes see Art. 502.]

529. Temporary Enclosing. [As specified in Art. 511, except that it is well to enclose a brick building as soon as the roof is on.]

530. Furring, Grounds and Corner-Beads. [The furring and putting on of the grounds, etc., of a brick building is done in the same way as in wooden buildings (see Art. 508 for specifications) except that in brick buildings the walls are usually furred or strapped, in which case the grounds are nailed to the furrings. If the plastering is applied directly to the brick walls it is advisable in good work to specify grounds behind picture-moldings, chair-rails, etc.] Wall-strapping may be specified as follows:

The outside walls are to be furred for lathing with 1 by 2-inch spruce strips, 16 inches on centers, straight and plumb and well-nailed to the walls. Outside stone walls are to be plugged every 16 inches with wooden plugs to receive the furring. [Or, porous terra-cotta blocks, or some approved form of metal wall-plugs, are to be furnished for nailing. See Art. 361, "Building Construction and Superintendence, Part I, Masons' Work," by F. E. Kidder.]

[Where the furring is nailed to wooden plugs it is well to specify 1¼-inch furring for greater stiffness.]

531. Mineral-Wool Lining. Mineral wool is to be packed between the sheathing and laths of second-story bay, from the sole to the plate; the space,

also, between the floor-joists of bay and on top of the matched sheathing, is to be filled in to a depth of 3 inches. (The spaces in walls of bath-room around plumbing-pipes, etc., are to be filled as specified in Art. 509.)

532. **Preparation for Tiling.** The floors of bath-room, vestibule and front porch are to be prepared for tiling (as specified in Art. 506).

533. **Underflooring.** [Same as in Art. 507. Boards to be cut close against all outside walls.]

534. **Mice-Stops.** [Around partition studs, as in Art. 509; outside walls are usually stopped by plastering between the grounds just above the floor.]

535. **Cutting and Fitting.** The floors are to be cut for registers and hearths as may be required and are to be cut, also, as required for furnace-pipes, steam-pipes, gas-pipes and plumbing-pipes, repaired neatly afterwards. No important timbers are to be cut except with the approval of the architect.

4. GRAVEL ROOFING AND SLATE ROOFING.

536. **Gravel Roofing. Western Method.** This is to be included in the carpenter's contract. The flat roof is to be covered with five-ply gravel roofing put on in the best manner. The first layer is to be of heavy, dry felt, put on with a 2-inch lap. The other four layers are to be of —— brand, saturated felt, (25) pounds to the square. The covering is to be put on in courses parallel with the eaves, each layer lapping the one below 27 inches, so that the roof will have five layers in thickness over all its parts, and it is to be well mopped with hot pitch for a distance of 9 inches from the edge. The felt is to be secured to the roof by threepenny nails furnished with tin discs and driven in rows 10 feet apart and 12 inches apart in the rows.* The entire surface of felt and flashings and the surfaces back of the fire-walls are to be covered with a continuous and even coating of straight-run coal-tar pitch; this is to be covered immediately with a sufficient body of well-screened gravel. If the roof is laid in cold weather, the gravel is to be applied hot.

Flashing. The roofing against fire-walls, chimneys, scuttles and skylights is to be finished by turning the felt up 4 inches against the walls. Over this an 8-inch strip of felt is to be laid with half its width on the roof. The upper edge of the strip and the several layers of felt are to be fastened to the walls by laths or wooden strips securely nailed, and the strip of felt is to be pressed into the angles of the walls and cemented to the roof with hot pitch. The lower edge of the strip is to be nailed to the roof every 4 or 5 inches. Especial care is to be taken in fitting around the angles of chimneys and skylights. The felt is to be extended 6 inches up on the sloping roof, and secured every 4 inches with threepenny nails with tin washers.

537. **Gravel Roofing. Eastern Method.** (In the New England States the saturated felt is often put on one layer at a time, in which case the first paragraph above should read as follows):

The flat roof is to be covered with one layer of heavy, dry felt and four layers of saturated felt (weighing 25 pounds to the square), lapped 3 inches

* This is not always done.

and the edges cemented with hot pitch. Each layer is to be laid separately, and the last two layers are to be laid in hot pitch. The last layer is to be secured to the roof, at the laps, by threepenny nails with tin washers, spaced 30 inches apart. The pitch and the gravel are to be the same as above.

(Still another method of applying the saturated felt is to apply three layers as in the Western method, each layer lapping 24 inches, then to cover with pitch and apply one or two more layers of felt separately in hot pitch. This makes a very good and durable roof.)

Flashing. The felt is to be turned up against fire-walls, chimneys, skylights and rising-parts 4 inches, and flashed with strips of zinc (or ——— tin), turned up 5 inches against the walls and extended 3 inches on the roof, with the lower edge secured by threepenny nails, spaced 1 inch apart. This flashing is to be covered with 4-pound lead or 14-ounce copper let into joints in the brickwork at least 1 inch and secured by wooden plugs.

The counterflashing is to come within 2 inches of the roof-surface; and on the scuttles and skylights it is to be turned over the top of the curb.

The joints in the underflashing are to be soldered in a substantial manner.

The eave-stops are to be formed on the gutter, which is to be put up by the metal-workers.

The entire job is to be done in a thorough and workmanlike manner, and is to be accompanied by a written agreement or bond to repair all leaks within the term of three years from completion, without cost to the owner.

538. **Slate Roofing.*** [To insure the best results, a separate contract should be made in all important cases. Ordinary work, however, can be included in the carpenter's contract. The following is given as an example of one type of slate-roofing specifications]:

Preparing the Boarding for the Slate. All boarding which is to be slated is to be covered with two good layers of black ——— paper (or paper of same quality) weighing 20 pounds to the square, carefully laid with a lap of 3 inches in every course, and thoroughly fastened to the roof-boards with nails driven through tin discs, previous to the slating. All roofs and also all cheeks of dormers, are to be covered with best quality ——— black (——— red, ——— green, ——— mottled green, or purple) slate. No slate is to be less than 3/16 (1¼ inches or ⅜ of an inch) of an inch thick (or thicker, if so specified), and all slates are to have holes for nails bored and countersunk. Slates are to be laid with 3-inch head-cover. All slates are to have both surfaces smooth and straight, and all corners are to be cut full and square.

Rendering.† The slates at the hips, valleys, ridges and chimneys are to be carefully laid in elastic, oil-cement of best quality for a distance of 2 feet from hips, valleys, ridges and chimneys, and are to be laid "close

* Much valuable data for the revision of this article was furnished by the Maine Slate Company of Monson, Boston, Mass.

† Much of the slate roofing is done without any rendering at all. For good work, however, the slates at hips, ridges and valleys should be bedded in elastic or slaters' cement, and if the roof is less than "one-third" pitch, all of the slates should be rendered as here described.

finish"; that is, with the metal cut to size and inlaid with slate-cement and thoroughly flashed with 14-ounce copper (or 16-ounce copper). All slates are to be nailed with galvanized nails (copper nails); the eave-courses are to be laid with double slating. In fitting the slates at the hips, valleys and ridges of the different roofs, particular care is to be taken to have the slates show the same line; this may require, in some places, slates of greater width than specially called for, and these are to be furnished as required.

Flashing. All scuttles, skylights, dormers and parts of masonry coming in connection with the roof are to be flashed in the best manner with 14-ounce copper (16-ounce copper), 7 inches wide and turned up 3½ inches.

Aprons. Aprons of the same material, 10 inches wide, are to be put on at the lower sections of the roof, which come against walls or of roofs of a different pitch. Aprons are to be put under dormer-window sills, nailed to the inside of the sills and extending 3 inches onto the slates.

Countrflashing. All underflashings against masonry are to be counter-flashed with 3-pound (4-pound) sheet lead (or 16-ounce copper), worked 2 inches into the joints of the masonry, and cemented in with best-quality elastic oil-cement. All work is to be done as required by the architect.

Cresting-Finials and Hip-Rolls. These are to be furnished and put on by the metalworker.

[There is a growing tendency to use rough, thick slates in graduated courses and random sizes, reproducing the effects of old English roofs.* This method of laying the slates gives a wide range for the carrying out of architects' ideas in regard to texture, color and arrangement.]

5. INTERIOR FINISH.

539. **General Conditions.** All the stock for interior finish of every kind is to be of the very best quality, free from knots, or sap, thoroughly seasoned and kiln-dried (and of selected grain). All is to be smoothed, scraped and sandpapered by hand before it is put up, and on completion, the work that is to have a natural finish, is to be properly cleaned and freed from all stains and finger-marks.

No interior finish of any kind is to be taken to the building until the plaster is thoroughly dry, and all hardwood finish and flooring are to be taken direct from the drying-kiln to the building.

All molded work is to be stuck in accordance with the full-size sections.

540. **Finishing-Woods.** The laundry, kitchen and rear hall are to be finished in selected long-leaf pine (excepting doors, which are to be of white pine). The front hall and vestibule in first story, including the stairway to second story, are to be finished in quarter-sawed white (red) oak (any of the hardwoods, cypress, redwood, etc.).

The parlor is to be finished in selected (mahogany) of a uniform dark color.

[See Art. 67.]

* Further data may be had in regard to the subject of "Old English Slate" upon application to the Old English Slate Company, Boston, Mass.

The dining-room is to be finished in selected (brown ash); library and butler's pantry in cypress.

The front chamber in second story is to be finished in selected (bird's-eye maple); balance of second story is to be finished in (whitewood, also called poplar) for staining, or varnishing in natural color.

All other rooms and closets (except cedar closet) throughout the building are to be finished in white pine (western white pine, larch, whitewood, also called poplar, etc.) for painting.

[Other finishing-woods that may be used are cherry, chestnut, beech, birch, butternut, various mahoganies, black walnut, gum, redwood, Circassian walnut, Douglas fir, sugar pine, and numerous others.]

541. **Doors.** All doors (except stock doors) are to be paneled and molded in strict accordance with the scale and detail drawings furnished for the same. All panels are to be loose and neither glued nor nailed. All tenons are to have ¾-inch haunches.

Veneered Doors are to have staved-up, thoroughly kiln-dried white-pine cores, with solid moldings and ¼-inch veneering of kiln-dried wood, well-glued on both sides.

Sliding Doors are to have an astragal-joint (he and she) in the center and ⅝ by 1¼-inch friction-molds on all edges.

Front Doors. The front doors are to be (2 inches) thick, veneered on both sides with clear, quartered (white oak) and paneled as shown, with raised panels and moldings with a (¼-inch) turned bead set in the moldings.

Vestibule-Doors are to be made to correspond with outside doors, except that the upper panel of each door is to be glazed with polished plate glass with a (2-inch) bevel. Front and vestibule-doors are to have astragals worked from 2 by 3-inch oak, glued to the meeting-stiles of the swinging leaves.

Kitchen, Basement and Other Doors. The kitchen and basement outside doors are to be made of clear, well-seasoned, white pine (Douglas fir), 1¾ inches thick, with (four) plain panels and flush moldings, (or are to be four-panels, ogee (O. G.) stock doors, first-quality, and 1¾ inches thick).

All doors opening into first-story hall, parlor, dining-room, library and second-story front chamber, are to be 1¾ inches thick, with five raised panels and flush moldings. All are to be veneered with the same kind of wood as the finish of the rooms.

Doors opening from any of these rooms into closets, are to be veneered on both sides with the same kind of wood.

All other doors in second story are to be (1½) inches thick, made of solid whitewood and paneled with five panels with flush moldings.

Sash Doors. The door from laundry to basement-hallway is to have the upper part divided into (six) lights by wooden muntins, and is to be glazed with chipped (ribbed) glass; the glass and labor for glazing are to be furnished by the carpenter.

Battened Doors.

All Other Doors. All other doors throughout the house are to be four-

panel (O. G.) stock doors (1⅜ inches) thick (with plain panels and flush moldings on both sides). The doors opening into kitchen, rear hall and laundry are to be first-quality, free from sap and knots, and cleaned up for varnishing. All others are to be (B) doors.

542. **Door-Frames.** All inside doors are to have 1¾-inch rebated and beaded frames of solid pine or whitewood for the pine and whitewood doors, and are to be veneered with ½-inch veneer in rooms finished in hardwood. Where a door is between rooms finished in different woods the frame is to show the corresponding wood on each side (or all inside doors are to have (1⅛-inch) frames with 1¾-inch O. G. stops, glued and braded to the frames). Frames are to be blocked solid for the hinges.

Where a door opens between rooms finished with the same kind of wood, the frame is to be solid; but where the adjoining rooms are finished with different woods, the frame is to be veneered with ½-inch veneers of the corresponding woods on ⅞-inch pine cores.

All frames are to be set square and plumb.

Thresholds.

[In some localities called "saddles."]

All inside doors are to have ⅝-inch molded thresholds of quartered oak for veneered doors and of long-leaf pine (Douglas fir) elsewhere.

543. **Wainscoting.** *Ceiled Wainscoting.* The walls of kitchen, laundry and rear hall from basement to third story, are to be wainscoted (4 feet) high with (¾ by 4-inch) center-beaded (three-beaded) clear, long-leaf pine ceiling, finished with a 1⅛-inch rebated cap but with no base.

Molded Ceiling. The dining-room is to be wainscoted (3 feet 6 inches high) with ⅞-inch molded (ash, oak, cypress, cherry, etc.) ceiling, stuck in two patterns as per full-size sections and finished with a (8 by ⅞-inch) molded base, a (5-inch) plain necking with a ⅝ by 1½-inch molding just above the wainscoting, and a 1⅜ by 1½-inch molded cap. The bottom of the ceiling is to be cut on top of a 1⅛-inch beveled strip, placed back of and ⅜ of an inch above, the base.

A ⅜ by ⅞-inch O. G. stop is to be scribed against the wall on top of the cap.

Paneled Wainscoting. The front hall and vestibule in the first story, the wall-side of the stairs from first to second story and the library, are to have paneled wainscoting (3 feet) high, divided into panels as shown on scale drawings. The panels are to be raised and molded as per full-size details. The framing is to be ⅞ of an inch thick and the panels put in loose; cap is to be molded with two members and to have a (¼-inch) turned bead; the base is to be 6 inches high and molded.

544. **Bases.** The parlor is to have a skirting (20 inches) high with a (5-inch) base; a 12-inch dado veneered on a staved-up white-pine core; and a two-member sur-base to match the window-stool and apron and to intersect with them. The dado is to be fastened at the top only.

All rooms and passages in second story (except bath-room and rear hall) are to have a (8-inch) molded base with a 2½ by ⅞-inch molding on top, and are to have, also, a (1⅛-inch) sub-base. The base-molding is to be rebated over the base and the base is to be tongued into the sub-base.

All third-story rooms and the laundry are to have an 8-inch O. G. base. Closets are to have a 7-inch plain base with beveled top.

(All bases are to be ploughed at the angles and put on before the overfloor is laid; an extra space of ½ an inch is to be allowed below the top of floor.)

Carpet-strips. Quarter-round carpet-strips, ¾ of an inch in size and of the same wood used in the base, are to be put around all floors and nailed to the floor and not to the base.

[When the upperfloor is butted against the base, carpet-strips are not needed.]

545. Door and Window-Trim. The doors and windows in principal rooms of first story are to have 5 by ¾-inch molded casings with 1⅜-inch molded back-bands mitered at the angles. Back-bands are to have ⅜-inch turned and quartered bead-moldings. Doors are to have (8-inch) molded plinths.

The trim in parlor is to have a (1⅛ by 10-inch) frieze with molded and dentiled cornice.

All doors and windows in second and third stories are to have 5½-inch pilaster-casings, with turned corner-blocks 1 inch thick, and plain 1⅛-inch plinths (10 inches) high. Doors and windows in laundry, kitchen, pantries and rear hall are to have 5-inch O. G. casings.

Bedroom closets are to have 4½-inch plain casings.

Windows are to have ⅞-inch subjambs with box casings veneered with ⅜-inch strips in all rooms finished in hardwood; and 1⅛-inch molded stools and 4-inch molded aprons. Stop-beads, ½ an inch thick and of the same kind of wood as the finish of rooms, are to come flush with the box casings, and in first story are to be returned on top of the sill.

Paneled subjambs, shutter-boxes and paneled backs, if included, are to be specified here.

546. Inside Shutters. (——— patent folding inside blinds for the windows in (parlor, dining-room and library) 1⅛ inches in thickness, and of the same kind of wood as the finish of rooms, are to be provided and hung. They are to be made in two sections, upper and lower, and in six folds for all windows 3 feet 6 inches wide and over, and in four folds for all others. The middle folds are to be fitted with rolling slats and the side folds with panels.

547. Venetian Blinds. Venetian blinds with 2-inch maple slats, metal ladders, braided, linen cords and bronze fixtures complete are to be furnished and put up for the windows of (second-story front chamber).

548. Inside Sliding-Blinds.

[See Art. 276.]

549. Finish of Blinds. All inside shutters, Venetian and sliding blinds are to be finished at the factory to match a finished sample obtained from the painter. All are to be rubbed down to a dull, gloss finish.

550. Picture-Moldings. The carpenter is to put a picture-molding of same kind of wood as the finish of rooms, around the walls of the principal rooms of first story, and the walls of all bedrooms. They are to be 1⅛ by 2½ inches in size in first story and ⅞ by 1¾ inches in bedrooms, all stuck according to details. The picture-moldings in the parlor and library are to

have ½-inch turned and quartered bead-molds and are to be placed ½ an inch below the wooden cornice; elsewhere they are to be placed 18 inches below the ceiling. The painter is to finish the picture-moldings, with the exception of the last coat, before they are put up.

[If gilded or ornamental picture-moldings are desired, it is better to include them with the decoration.]

551. **Chair-Rails.** A (1⅛ by 4½-inch) molded (ash, or other suitable hardwood) chair-rail to match the other finish of the room, is to be put around the (dining-room). The top is to be (3 feet 2 inches) from the floor.

552. **Angle-Beads.** (1⅜-inch) turned angle-beads (4 feet 6 inches long) with turned ornaments at the ends are to be put on all projecting plaster angles and are to be of the same kind of wood as the finish of room.

[Or as described in Art. 232, Chap. V.]

553. **Door-Stops or Bumpers.** Hardware door-stops with inserted rubbers are to be put in the base or floor where required to stop the doors. Where rooms are trimmed with hardwood they are to match the trim; elsewhere they are to be of oak or ash.

[These are often included in the hardware specifications and specified by manufacturers' name and number.]

554. **Wooden Cornices, Ceiling-Beams, etc.** The parlor is to have a mahogany (or other suitable finishing-wood), cornice extending (10 inches) on the ceiling and (9 inches) on the walls, with dentils, (modillions) and turned beads, as per scale and full-size details.

The library is to have a wooden ceiling with false beams and wooden cornice, all of cypress (or other suitable finishing-wood), the beams intersecting with the cornice. The panels between the beams are to be filled with ¾ by 2½-inch (double) beaded ceiling, put on diagonally in some of the panels and at right-angles to the floor-joists elsewhere. A (⅞ by 1-inch) bed-mold is to be put around all panels.

The beams are to drop (6 inches) below the panels and are to be built up of ⅞-inch stock with paneled soffits and square panels at the intersection. The cornice below the wall-beams is to have one row of dentils and one row of (⅞ by 1-inch) egg-and-dart molding, carved by hand (machine).

All wooden cornices are to be fastened with brads and glue in the best manner, solidly blocked and put together in lengths at the shop. Nails are to be concealed as far as possible. All dentils are to be cut on a strip and not put on separately.

555. **Splicing of Finish, Nailing, etc.** No splicing of the door-trim or window-trim is to be allowed, and joints of bases, chair-rails, picture-moldings, etc., are to be carefully matched. All molded finish is to be braded in the quirks of the moldings, and all finish-nails are to be set in for puttying.

[If the door-trim and window-trim are to be put together on the bench, as described in Art. 264, they should be so specified here.]

556. **Preliminary Finish of Hardwood.** This contractor is to finish all of the hardwood trim (and doors) of (hall, parlor, dining-room and library) before it is put up or "hung," as follows:

[Here specify the kind of finishing-material, number of coats, rubbing, etc., desired.]

The final coat is to be given by the painter when the carpenter's work is finished.

Panels are to be finished with all but the last coat before they are put in the frames. All hardwood finish is to be painted one good coat on the back.

557. **Stairs.** The front stairs from the first to the third stories are to be supported on (2 by 12-inch) well-seasoned white pine (spruce, Douglas fir, long-leaf pine) "carriages," carefully shaped to fit the treads and risers, and set level and true in line. There are to be four carriages and a 3 by 4-inch wall-bearer for stairs from the first to the second story (Fig. 533), and three carriages from the second to the third story. The wall-bearers are to be securely spiked to the walls. Landings are to be formed of (2 by 8-inch) joists. The rough work of the stairs is to be firmly put up, and is to be self-supporting without the aid of angle-newels.

No finished work is to be put up until the plaster is dry.

Curb-String Stairs. The stairs from the first to the second story are to have curb-strings, 1⅛-inch treads, ⅞-inch risers and 1⅛-inch wall-strings. Treads are to have molded nosings with (¾ by ⅞-inch) moldings underneath. The treads are to be ploughed into the risers, and the risers into the under side of the treads, and both are to be housed into the wall-strings [Pennsylvania method, Art. 300], and wedged and glued from the wall-bearers. The wall-strings are to be rebated on top and capped with base-molds to match the base in the hall. The inside face of curb-strings is to be dadoed into the treads and risers. The outside face of strings is to be paneled as per scale details with 1⅛-inch framework, flush (raised) panel-molds and (raised) panels, all carried around the stair-well. The curb-string is to be capped with a (1⅛ by 6-inch) piece, molded and rebated to fit over the string, with a ⅞ by 1½-inch molding planted on the string under the cap, and with a turned bead let in, all as per full-size details. A (⅞ by 1⅝-inch) molding is to be cut in between the balusters.

Newels. The main newel-post is to be (6 by 6 inches in size), built up, fluted (paneled) on all four sides and is to have a molded and turned cap with one (carved) member, neck-molding and hand-carved rosettes. It is to have, also, a ⅞-inch molded base.

All other newels are to be (5 inches) square, fluted newels, with molded and turned caps, neck-moldings and rosettes in the neckings. A turned ornament is to be put on the bottom of each drop-newel.

The rail is to be double-molded out of (3¾ by 3⅜-inch) stock [see Fig. 535], with ramps and easings at all newels. Sections of rail are to be bolted together and to newels.

Balusters. Balusters 1⅛ inches square are to be turned to (three) patterns and are to be set (3½ inches) on centers.

Molded panels about (12 inches) wide to center of rails are to be used for paneling under the rake of the first flight and on all soffits. Stiles and rails are to be 1⅛ inches thick and plain panels are to be used.

Open-String Stairs.

[Boston method, Art. 299.]

The front stairs from the second to the third story are to have open-strings, molded nosings with ⅞-inch coves underneath, returned at the ends and carried around the stair-well, 1⅛-inch treads and ⅞-inch risers, the treads ploughed into the risers, and the risers into the under side of the treads, and the base dadoed into both; (1 inch) turned balusters (three) to a tread and around the stair-well, in same proportion, all dovetailed at the foot and tenoned into the under side of the rails; (3½ by 3½-inch) double-molded hand-rails, with no ramps, 4 by 4-inch solid, turned newels at the angles with caps and neck-molds and half-newels at the upper terminals of the rails. The newel at the foot of the stairs is to be 5 by 5 inches, boxed, carved and fluted, and finished with a molded cap and base.

The base on the wall-side of the stairs is to be rebated and is to have a 2½ by ⅞-inch molding to match the base around the hall. All stock is to be clear, kiln-dried (whitewood, cypress, white pine, or any of the hard-woods, etc.), put up in the best and strongest manner. The stairs are to be furred on the under side for plastering.

Rear Stairs. The rear stairs from the first to the second story are to have open strings, rounded nosings with coves underneath, returned at the ends and carried around the stair-well, ⅞-inch risers and treads, the treads ploughed into the risers, and the risers into the under side of the treads, and both treads and risers ploughed for the base on the wall side; (1 inch) plain, round balusters (three) to a tread and around the stair-well in the same proportion, mortised at the top and bottom; 2¼ by 3¾-inch plain, molded hand-rail newels, and 3¾ by 3¾-inch solid, turned, chamfered and fluted newels at each angle and at the foot, with half-newels at the upper ends of rails; and all are to be of long-leaf yellow pine (Douglas fir, Norway pine), throughout.

Attic-Stairs (built between partitions). The rear stairs from the second to the third story are to have 1⅛-inch treads and ⅞-inch risers, tongued and grooved together and housed into the wall-strings. The treads are to have rounded nosings with coves underneath. The wall-strings are to be full 1¼ inches thick, spiked to the studding and rebated on top with base-molds to correspond with the adjoining base.

The treads, risers and strings are to be of clear, well-seasoned white pine (Douglas fir, Norway pine, long-leaf pine), put up before plastering, wedged and glued from below, and furred on the under side with 2 by 4-inch stock, for plastering. The stairs are to be protected with sheathing-paper and boards until the carpenter's work is completed. A 2-inch round (ash) hand-rail, secured with iron brackets and with ends returned against the plastering, is to be put up on one side of the stairs.

Cellar-Stairs. The cellar-stairs are to have (three) 2 by 10-inch surfaced-spruce carriages, 1⅛-inch long-leaf pine treads, rounded nosings, and ⅞-inch risers, nailed to carriages; 4 by 4-inch turned and chamfered whitewood newels and two 2 by 4-inch whitewood rails, rounded on top and beaded on each side.

Winter Steps for Front, Stone Steps.

558. Arches, Seats, etc. (coming in connection with the front stairs). The stair-builder is to furnish and put up the wooden arches, screens and

seats dividing the staircase from the main hall, as shown on the scale-drawings and full-size details; all are to be of quarter-sawed kiln-dried white oak (cypress, chestnut, etc.).

The backs of seats are to be framed with flush panels and turned-bead, flush panel-molds. The ends of the seats are to be paneled, molded and carved as shown. The seats are to be stationary, molded out of 1¾-inch plank (or hinged with bronze butts for raising). The risers are to be paneled.

Mantels, Sideboards, Bookcases, Mirrors.

559. **Butler's Pantry.** The butler's pantry is to be fitted up as indicated on the drawings, with a counter-shelf (2 feet 4 inches) wide and (2 feet 8 inches) high all around. (Five) ⅞-inch shelves (11½-inches) wide are to be put above the counter-shelf. The top shelf is to be (8 feet) above the floor, and is to be (14 inches) wide, fitting tightly against the back of the cornice. The shelves are to be enclosed with 1¼-inch sash-doors, divided into (four) lights each and glazed with first-quality AA double-thick glass. The doors on the (south) side are to be arranged to slide on brass tracks, are to be fitted with 1¾-inch brass-wheel anti-friction sheaves and are to slide into rebated frames.

The doors elsewhere are to be hinged at the sides and are to have dust-proof joints as per detail-drawings. A ⅞ by 4-inch molded cornice is to be put above all doors, and 1¾-inch rebated frames (see Fig. 548) are to be made for the swinging doors.

(Six) drawers with lip-fronts are to be provided and placed below the counter-shelf, with one drawer divided for knives, etc. The remaining space is to be divided into cupboards with 1⅛-inch (O. G.) paneled doors, and one shelf in each cupboard. The sink is to be fitted up with a 1⅛-inch grooved, drip-board and frame with an apron underneath. All of this work (except the lower shelf) is to be of kiln-dried (cypress) left clean for a natural finish.

[In the more recent practice very little wood is used in connection with plumbing-fixtures.]

560. **Kitchen-Pantry.** The kitchen-pantry is to be fitted up as indicated on the floor-plans in clear, white pine (cypress), for natural finish. (Five) shelves (11½ inches) wide are to be put up above the counter-shelf, supported on neat cleats with (three) standards from bottom to top, neatly let in and chamfered.

(Two) barrel-cupboards are to be fitted up with (O. G.) paneled doors and lifting covers (or two flour-bins 18 inches wide, 16 inches deep and pivoted at the bottom, are to be fitted up).

The remaining space under the counter-shelf is to be taken up partly with one case of three drawers with lip-fronts and partly with paneled doors about (16 inches) wide, with one shelf back of them.

Six pot-hooks are to be furnished and put up where directed.

561. **Kitchen-Dresser.** The dresser in the kitchen is to be constructed and set up, and is to be (4 feet 6 inches) wide and (8 feet) high, including the cornice, and made according to the drawings, of clear, kiln-dried (long-leaf yellow) pine (Douglas fir), for a natural finish. It is to have a counter-shelf (2 feet) wide and (2 feet 8 inches) from the floor, with two sliding

shelves underneath. The portion above the counter-shelf is to have four shelves (11½ inches) wide, enclosed with three paneled doors, 1⅛ inches thick and hinged at the sides.

Three drawers 2 feet long and 20 inches deep, with paneled fronts and two 1⅛-inch paneled doors, are to be fitted up below the counter-shelf. The dresser is to have paneled ends, solid top with a neat cornice, and a 1⅛-inch beaded frame for the doors. The doors and drawers are to be trimmed with suitable hardware in (amber) bronze.

562. Cedar Closet. After the cedar closet is plastered, the entire inside walls, ceiling, floor and inside of door, are to be lined with (½ by 2½-inch) Florida (western or Alabama), red cedar; tongued, grooved, and blind-nailed.

The closet is to be fitted up with drawers and shelves as marked on drawings. The counter-shelf is to be (20 inches) wide of Florida (western or Alabama) red cedar. (The drawer-frame may be built of white pine (whitewood), veneered on the outside with cedar, but the drawers are to be entirely of cedar.)

563. Linen-Closet. The linen-closet is to be fitted up in clear, white pine (whitewood) and left ready for varnishing. It is to have a counter-shelf 24 inches wide, 3 feet from the floor, and three drawers below (4 feet) long and 22 inches deep, with lip-fronts. The bottom of the lower drawer is to be 3½ inches above the floor and there is to be an O. G. base below.

(Four) shelves (20 inches) wide are to be put above the counter-shelf, and enclosed with 1¼-inch paneled and molded doors (5 feet high), hung at the sides (or arranged to slide on a brass track by means of brass sheaves). A 1¼-inch beaded frame is to be made, set in place, and finished on top with a 3½-inch crown-mold.

564. Medicine-Chest. The medicine-chest or medicine-closet is to be constructed in the bath-room partition of clear (whitewood) and left ready for varnishing. The sides, top and bottom are to be (1⅛-inches) thick, the bottom projecting (1 inch) beyond the door and molded (with a molded apron underneath).

The back is to be ceiled with ½ by 2½-inch ceiling; (three) shelves, ½-inch thick are to be put up; and a 1¼-inch one-panel door is to be hung in front and glazed with a French-plate-glass mirror with a thin board behind it. The door is to be trimmed with solid-bronze trimmings.

[The medicine-closet usually comes just above the wainscoting.]

565. Bedroom-Closets. All bedroom closets are to have one (12-inch) long-leaf yellow pine (whitewood, Douglas fir) shelf, put up on neat cleats. Beaded strips (3½ inches) wide, for clothes-hooks are to be put up around all closets.

The closets for (bedrooms Nos. 1 and 3) are each to have a case of three drawers as long as the space will permit, (16 inches) deep, with paneled fronts and a counter-shelf above, finished with a rounded edge and cove; and with a 3-inch O. G. base below the drawers. All the work in the bedroom closets is to be of (clear) white pine (whitewood, Douglas fir), (for painting).

Coat-Closets.

Other Closets.

Drawers. All drawers are to be dovetailed together, each with the bottom grooved into the sides, and are to run on hardwood strips.

The drawers in (linen-closets and cedar closets) are to be fitted with the (——— ball-bearing drawer-slides).

566. Ventilation of Closets. Each closet (in the second story) is to be ventilated by means of a (3½ by 10-inch) tin pipe, placed in the partition, run to the air-space above the third story and covered with a wire netting at the top.

The vent-pipes are to be connected at their lower end with 8 by 10-inch (white, enameled) register-faces set in the wall just below the ceiling; they are to be furnished and set in place by the (carpenter).

567. Kitchen-Sink. A strong frame is to be made to support the kitchen-sink. It is to be furnished with a 1⅛-inch frame of (ash) (cypress), mortised and tenoned together and with grooved drip-boards at each end. A 4-inch apron is to be placed underneath. The projecting corners of the frame are to be supported with (3½-inch) turned legs of hard pine (or heavy japanned-iron brackets) (or the same material as the wainscoting is to be used for ceiling under the sink, with one paneled (battened) door, hung with brass hinges and furnished with a brass catch).* One 12-inch shelf is to be put under the sink. Two drawers each 4 inches high and 16 inches deep are to be put under one end of sink and to run on hardwood strips.

568. Wash-Trays.† Where shown on drawings stationary wash-trays in (two) sections are to be constructed and set in place. They are to be made of clear, seasoned, white pine, 1¾ inches thick, rebated and put together with tight, white-lead joints. The trays are to be 14 inches deep inside, 30 inches long, 22 inches wide across the top and 16 inches across at the bottom, with the fronts beveling; and they are to be set on a substantial frame, made level and true. Each tray is to have clamp-flaps, hung with heavy, brass butts.

569. Bath-Room Fixtures. The plumber is to furnish all the woodwork ‡ connected with and a part of the bath-room fixtures themselves, but the carpenter is to put up the tank and the water-closet seat in a neat and substantial manner.

Plumbing-Strips. Neat beaded strips of the same kind of wood as the finish of the rooms are to be put up for the plumbing-pipes where they are exposed.

Pockets are to be formed in the walls and partitions where indicated on the drawings and they are to be provided with removable (paneled) fronts, let flush into rebated strips on each side and secured with brass (japanned) buttons.

Clothes-Chute.

* In the best modern practice the use of wood, in connection with plumbing-fixtures, is omitted entirely or reduced to a minimum.

† This type of wash-tray is now practically obsolete. Those used to-day are constructed of porcelain, porcelain-lined metal, soapstone, etc., and vary somewhat in their measurements from those here given. See catalogues furnished by the different manufacturers.

‡ In the best modern practice the use of wood, in connection with plumbing-fixtures, is omitted entirely or reduced to a minimum.

570. **Dumb-waiter.** The dumb-waiter shaft is to be lined with ¾ by 4-inch long-leaf yellow pine ceiling. A pocket is to be arranged for the weight with pocket-pieces secured with screws. Paneled doors (2 by 3 feet) are to be made for the openings in kitchen and pantry, and are to be hung with 2-inch steel-axle sash-pulleys, ——— sash-cord and iron weights, carefully balanced. A narrow shelf is to be put at the bottom of the doors and the latter are to be provided with suitable hardware.

The car is to be constructed 24 by 20 inches in plan and 30 inches in height, of clear, white pine (ash, or other suitable wood), ⅞ of an inch thick, dovetailed together and fitted with two shelves. It is to be hung with ——— safety, dumb-waiter fixtures with the best ½-inch pliable, cotton rope, put up in a substantial manner and left in complete working order. The car is to be exactly balanced by an iron weight.

571. **Overflooring.** Where there is a double floor the overflooring is not to be laid until the standing finish is all in place.

All underfloors or subfloors are to be thoroughly repaired and cleaned before the overfloors are laid.

Sheathing-Paper. One thickness of (——— double-ply) parchment sheathing is to be laid between the over and underflooring throughout first story, and one layer of ——— double-ply, asbestos-covered deafening-quilt is to be laid between the floorings throughout the second story. Three-eighth inch strips are to be nailed on top of the deafening-quilt over the line of the floor-joists.

Wherever floors have settled so as to be out of level, they are to be furred by strips set over the joists and sized to bring the overfloor to a true level.

Hardwood Floors. The front hall in the first story, is to have an overfloor of quarter-sawed white oak (maple) (⅜ by 1½ inches) (13/16 by 2¼-inches), matched, laid in herring-bone pattern, as per details, finished with a 14-inch border and blind-nailed in place.

The library and dining-room are to have *parquetry-floors* (included in another contract) 5/16 of an inch thick, laid over white-pine (Douglas fir, spruce) flooring.

[See Chap. V., Art. 330.]

The kitchen, butler's pantry, laundry and rear hall in first and second stories are to have an overfloor of 3-inch (4-inch) (2½-inch) first-quality, quarter-sawed long-leaf yellow pine (maple, Douglas fir) flooring, matched, blind-nailed and tightly laid.

The dining-room and library are to have an overfloor of 13/16 by 3¼-inch (1 5/32 by 3¼-inch) matched, second-quality, long-leaf yellow pine (Douglas fir, spruce) boards, blind-nailed, tightly laid, and planed to a perfectly level surface to receive the *parquetry-flooring,* which will be furnished and laid under another contract.

[See Chap. V., Art. 330.]

All other rooms and closets throughout the (first and second stories) are to have an overfloor of 13/16 by 3¼-inch "first" and "second" clear, long-leaf yellow pine (spruce, Douglas fir) flooring, matched and blind-nailed and tightly strained (or, to have an overfloor of ⅞ by 6-inch second-quality,

white-pine flooring) (or first-quality, spruce (Douglas fir) flooring), carefully jointed, laid to break joint every 2 feet, tightly strained and nailed over every bearing with two eightpenny floor-nails.

All end-joints in flooring are to be cut over a bearing in every case. Matched flooring is to break joint in every course. Borders are to be mitered around all hearths and registers. All overfloors are to be thoroughly kiln-dried, brought directly from the kiln to the building, and kept dry during the transfer.

All hardwood floors, including the long-leaf yellow pine (Douglas fir, spruce, maple) floor in kitchen, butler's pantry, laundry and rear hall, are to be smoothed and traversed by hand as soon as laid and are to have all plane-marks scraped out. Softwood floors are to have all ridges caused by uneven thickness smoothed off, but not traversed.

Protection of Floors. The carpenter is to call upon the painter to oil the long-leaf yellow pine (Douglas fir, spruce) floors that are to be traversed, as soon as they are smoothed. The carpenter is to protect the hardwood floors with two thicknesses of sheathing-paper, the under thickness being water-proof, properly put down and maintained in good condition until the painter is ready to begin the filling. The carpenter is to be responsible for the condition of these floors until that time.

6. CELLAR-WORK AND MISCELLANEOUS DETAILS.

572. **Partitions.** Board partitions are to be put up where shown on basement-plan, with 2 by 4-inch uprights set 3 feet apart, and one horizontal piece cut in between. All are to be of good spruce (long-leaf pine, Douglas fir) stock, surfaced on three sides. The partitions are to be ceiled vertically on one side only, with ⅞ by 6-inch good, sound, matched, long-leaf yellow pine (spruce, Douglas fir) boards, surfaced on both sides, set in a shoe at the bottom and cut to fit close against the plastering, floor-joists or underfloor at the top, as the case may be.

573. **Coal-Bins.** The coal-bins are to be built with (3 by 4-inch) studs, set 2 feet apart. They are to be ceiled on the outside to the ceiling of the room with (vertical) matched boards and sheathed up (4 feet) on the inside with 1-inch rough sheathing. The openings to the bins are to be provided with battened doors of matched boards, hung with heavy, strap hinges and provided with a good strong latch. Removable slides of 1⅛-inch boards are to be fitted inside of the door.

The floor in coal-bins is to be laid with 2 by 10-inch spruce (hemlock) planks, spiked to 4 by 4-inch spruce (cypress, cedar or redwood) sleepers, 2 feet apart.

574. **Storeroom.** The storeroom in cellar is to be fitted up on two sides of the room with (four 14-inch) long-leaf yellow pine (cypress, Douglas fir) shelves ⅞-inch thick. The shelves are to be supported on cleats with a 1⅛-inch standard in the center.

One hanging shelf 16 inches wide and 1⅛ inches thick is to be put up, and is to hang free from the walls.

575. **Wine-Cellar.** The wine-cellar is to be fitted up with ⅞-inch long-leaf yellow pine (cypress, Douglas fir) shelves, 10 inches deep and 9 inches

apart, extending from the floor to the ceiling. A ⅞ by 4-inch strip is to be nailed to the front edge of each shelf; half-round cuts, 1½ inches wide and 4 inches on centers are to be cut out for the bottles. All shelves in basement are to be surfaced on both sides and on the edges.

576. **Cold-Air Box.** A cold-air box is to be constructed from the opening in the outside wall to the duct under the cellar-floor, (12 inches by 2 feet) inside measurement, and is to be made of 12-inch long-leaf yellow pine (cypress, Douglas fir) boards, surfaced on one side, and of 4-inch matched flooring. The box is to be provided with a slide-damper and a door, opening into the cellar, hung with iron butts and secured with two iron buttons. An air-duct 10 by 12 inches is to be constructed from the register in the hall-floor, connected with the cold-air box below the damper and fitted with a sliding-damper.

577. **Ash and Garbage-Box.** A strong, double box of ⅞-inch matched-and-beaded, long-leaf yellow pine (cypress, Douglas fir) is to be made, to contain ash and garbage-barrels with a division between them. Each part is to have a battened door in front for removing barrels, furnished with a good lock and two keys, and with a lifting cover on top, hung with galvanized-iron (brass) butts and with galvanized (brass) hook-and-staple fastenings.

7. HARDWARE.*†

578. **First Method.** The contractor for the carpenter's work is to allow the sum of $—— for the hardware trimmings of all doors and windows, and of the fittings in cedar closet and butler's pantry, exclusive of sash-cord, weights and pulleys, tracks and hangers for sliding doors, hardware for outside blinds and shutters, grilles or wire for cellar windows, foot-scrapers and hand-rail brackets.

This allowance is to cover the net cost to the contractor, and the owner is to be permitted to select the hardware where he chooses, and is to have the benefit of any deduction from the allowance.

The contractor is to furnish the architect with a correct list of the hardware, and is to put it on in a careful and workmanlike manner.

He is also to provide and put any other hardware called for by the plans and specifications.

[Here should follow specifications for hanging double-hung sashes and sliding doors, and for cupboard and drawer-trimmings, unless previously specified. For hanging sashes and sliding doors, see Art. 581.]

579. **Second Method.** The contractor is to furnish and put on at the proper time and in a skillful manner, all necessary hardware trimmings and

* See also Arts. 445, 446 and 447, Chap. VI, referring especially to forms used in specifying hardware. The references in the following pages to different manufacturers of hardware are left as originally written by Mr. F. E. Kidder. The letters and numbers of various materials, finishes, etc., however, have been revised.

† Much valuable data for the revision of the hardware-section of this chapter was furnished by the following firms: P. & F. Corbin, New Britain, Conn.; the Russell & Erwin Manufacturing Company, New Britain, Conn.; Sargent & Company, New Haven, Conn.; the Stanley Works, New Britain, Conn., and the Yale & Towne Manufacturing Company, New York City.

fittings of the kind and quality herein specified. If any necessary hardware is omitted the carpenter is to supply the same to correspond with the hardware in the same room or closet.

All hardware is to be put on with screws to match the finish.

580. Ornamental Hardware. All of the hardware trimmings of doors and windows in the vestibule, first-story hall, parlor, library and dining-room are to be of (P. & F. Corbin's, Russell & Erwin's, Sargent & Co.'s, Stanley Works', Yale & Towne M'f'g. Co.'s, etc.) goods, of the designs and finishes indicated below, all the various pieces in the same room to have the same ornamentation and finish. In this particular article where goods are specified by number, Sargent & Co.'s catalogue is referred to unless otherwise specified.

Hall and vestibule, V F-design, O E, sand-finish.

Parlor, B A-design, dull-brass finish.

Library, B A-design, dull-brass finish.

Dining-room, B A-design, dull-brass finish.

Door-Hardware. Butts. The front doors are to be hung with three 4½ by 4½-inch heavy, solid, bronze butts to each door. The vestibule-door is to be hung with three 4½ by 4½-inch plated butts. All other swing doors opening into or from the hall and into or from the three rooms mentioned are to be hung with two 4 by 4-inch plated butts. All butts are to be of the plain, loose-pin type.

Locks, Knobs and Escutcheons. The front doors (pair of doors) are to be trimmed with cylinder-set No. OE5075VF double trim; vestibule-door with cylinder-set No. OE5075½VF.*

All other swing doors in the rooms above mentioned are to be trimmed with No. 5259P lock, with 2¼-inch round knobs and combined escutcheons of the ornamentation and finish above indicated. The face of the locks is to be finished to match the knobs.

The sliding-doors between library and parlor and between library and dining-room are to be trimmed with No. 6964P locks, with two large cup-escutcheons of the ornamentation indicated, on each door.

Flush Bolts, Cupboard-Doors, etc. The standing-leaf of the front doors is to have two No. 1116P flush bolts on the face of the door, 12 inches long at the bottom and 18 inches long at the top; finish to match.

One No. OE9184VF push-button is to be furnished for the front-door frame.

The cupboard-doors in dining-room are to be hung with 2½-inch light loose-pin, ball-tipped, solid-bronze butts, fitted with cabinet-locks and trimmed with cabinet-escutcheons No. 871RG; finish to match.

The drawers below the cupboard are to be trimmed with No. 800RG drop-handles, two to each of the long drawers and one to each of the short ones.

Window and Shutter-Trimmings. The double-hung windows in the rooms above mentioned are to be trimmed with Fitch bronze metal locks, No. 44 size, or bronze-metal sash-fasts No. 358P, finished to match as nearly as practicable the other hardware of the rooms. Two flush sash-lifts of the ornamentation indicated are to be put on each lower sash.

French Windows. French windows are to be hung with 3 by 3-inch light,

* These sets include lock, knobs and escutcheons.

loose-pin, ball-tipped, solid-bronze butts and trimmed with two mortise, flush bolts on the standing-leaf, and No. 5029P lock with lever-handle and combined escutcheon on the inside only. Bolts, levers, handles and escutcheons are to be of the same ornamentation and finish as the other hardware of the rooms, and the butts are to be finished to match; or a Yale & Towne Cremorne bolt, No. 160 plain, a Corbin espagniolette bar No. 069½, or a flush double-extension bolt, finished to match the other hardware of the room, is to be used for trimming; one bolt or bar to each window.

Shutters. The shutters in the rooms above mentioned are to be hung with 1¼-inch beveled shutter-flaps and three-fold pocket-hinges, bronze-plated and finished to match the other hardware of the rooms.

The shutters are to be trimmed with Sargent's shutter-bars and knobs, of the ornamentation and finish specified above.

581. **Plain Hardware.*** The hardware specified under this heading for the first and second stories is of very good quality, and probably more durable than that specified under Ornamental Hardware.

Door-Trimmings. Sliding Doors. All sliding doors (including those from the library) are to be hung with the Coburn trolley-track No. 2 and Coburn roller-bearing parlor-door hangers, securely put up and carefully adjusted.

Double-Action Doors. The double-action door between butler's pantry and kitchen is to be hung with two Bommer, 7-inch double-action hinges, japanned (or with one Chicago, double-action hinge and one blank, both japanned). This door is to be trimmed with two plain, wrought-bronze push-plates (3 by 11 inches), with beveled edges (and Yale dead-lock, No. 270B, with two No. DP812 key-plates).

[In restaurants, hotels, etc., double-action doors between the kitchen and serving-room or between the serving-room and dining-room should be trimmed with kick-plates, but in private residences they are seldom used.]

Balance of First Story. All other doors in first story are to be hung with two 4 by 4-inch (Stanley wrought steel) loose-pin butts, ball-tipped (and fitted with steel washers). Butts on doors opening into rear hall and lavatory are to be Bower-Barffed. All others are to be japanned finish. The outside door of rear hall is to be fitted with a Yale three-bolt lock, No. 1402 FX80. Balance of doors are to be fitted with Yale locks, No. 1500FX80, where hardware shows in hall and lavatory, and with No. 1500B elsewhere. A No. 44 Yale rim night-latch is to be put on the outside door of kitchen.

The doors showing in rear hall and lavatory are to be trimmed with Yale knobs, No. D35FX80 and No. 86 escutcheon, same finish. The outside door is to have same kind of knob on both sides, a No. 86FX80 escutcheon on the outside and a No. 86½FX80 escutcheon with a No. 35 thumb-knob on the inside.

The balance of doors in the first story are to be trimmed with Yale jet knobs, No. F205, and with No. 83 escutcheons in natural bronze.

Second-Story Doors. All second-story doors are to be hung with two (Stanley wrought-steel, No. 241½) 4 by 4-inch loose-pin butts, ball-tipped, bronze-plated and polished, and with natural finish.

* These sets include lock, knobs and escutcheons.

All bedroom-doors opening from hall or passage are to be fitted with Yale three-bolt chamber-door locks, No. 1402B. Doors between chambers are to be fitted with Yale communicating-door latches, No. 1525B. All other doors in second story are to be fitted with Yale locks, No. 820B.

All of these doors are to be trimmed with No. D35, Yale, bronze knobs and No. 86 escutcheons for locks; No. 86 escutcheons for outside of bedroom-doors; No. 86½ escutcheon with No. 35 thumb-knobs for inside of bedroom-doors; and three-bolt locks, No. 86 escutcheons and No. 35 thumb-knobs for communicating-latches; all in natural finish.

Closet-doors are to have the same kind of trim on both sides.

Third-Story Doors. All third-story doors are to be hung with 4 by 4-inch loose-pin (Boston-finish) (bronze-plated) iron butts, ball-tipped (with steel washers).

All the doors in this story are to be fitted with Sargent & Co.'s No. 5234 locks (or Russell & Erwin's No. 370 lock, or P. & F. Corbin's No. 785B lock*), and trimmed with 2¼-inch plain, bronze-metal, spun knobs and wrought-bronze escutcheons with rounded edges, 1⅞ by 5¾ inches or larger; all in natural finish.

Basement-Doors. The paneled doors in basement are to be hung with 4 by 4-inch japanned-iron butts (with steel washers), fitted with Sargent & Co.'s locks, No. 5234P, and trimmed with jet knobs, with japanned roses and key-hole-plates.

The battened doors are to be hung with 6-inch Stanley, corrugated, T hinges, No. 961, fitted with Russell & Erwin, No. 3806 rim locks, and trimmed with jet knobs, with japanned roses and keyhole-plates.

The basement entrance-door is to be fitted with 4-inch wrought-steel, japanned barrel-bolt with bent staple.

The doors to wine-cellar and store-closet are to be fitted with Yale mortise dead-locks, No. 304, and trimmed with japanned-iron pulls.

Transoms. The transoms over outside doors of rear hall, kitchen and rear balcony are to be hung at the bottom with 3-inch narrow butts, those in the hall being japanned and those elsewhere being bronze-plated. All are to be fitted with Yale transom-lifters, No. R153, Bower-Barff finished in hall and bronze-plated elsewhere.

All transoms over inside doors are to be pivoted at the sides with 1⅜ by 2⅝-inch open-socket sash-centers (Fig. 679), bronze-plated and fitted with Payson's "solid-grip" transom-lifters, No. 203, bronze-plated (or Yale, No. R153, or Russell & Erwin, No. 130½, 3-foot, bronze-plated), (or finished to match the other hardware of the room).

Window Hardware. Double-Hung Windows. The windows in second-story bay are to be hung with Pullman side-pattern balances, No. 16 (or Pullman tandem, side-pattern balances, No. 1016).

All sashes in box frames which are glazed with plate glass are to be hung with 2¼-inch Norris, bronze-metal face, noiseless pulleys, Samson, spot cord, No. 8, and iron weights carefully balances; or are to be hung with Grant, over-head, tape pulleys, with 2¼-inch wheels, electro-bronze faces, aluminum-

* These locks are all good one-tumbler locks, and of about the same grade; locks of a much higher grade are often used.

bronze sash-ribbons and iron weights carefully balanced; or are to be hung with Gardner, anti-friction, square-end pulleys, with 2¼-inch wheels, bronze faces, sash-ribbons, and iron weights carefully adjusted. Faces of pulleys in hall, parlor, dining-room and library are to be finished to match the other hardware of the room. Should any of the frames be too short for iron weights to work properly, Raymond's compressed-lead sash-weights are to be used instead of the iron weights.

All other double-hung windows are to be hung with 2-inch noiseless pulleys with turned iron wheels and square, bronze-plated (amber-bronze) fronts; Samson spot-cord (Silver Lake sash-cord), No. 8 size for all weights of 15 pounds and over and No. 7 for lesser weights; and with iron weights carefully adjusted.

Sash-Locks and Sash-Lifts. The sashes throughout the second story are to be trimmed with Ives cast-bronze sash-locks, No. 534 (Fitch sash-locks, No. 24, Sargent's, No. 860P), and plain, wrought- (cast-) bronze, flush, sash-lifts, two on each lower sash which is 30 or more inches in width, and one on all others. The lower sashes of bay windows [See Art. 429] are to have the combined sash-lift-and-lock, Russell & Erwin, No. 0776. A Willer, plain-bronze sash-lift is to be put on each upper sash about 12 inches above the meeting-rail.

One window in each second-story bedroom is to be fitted with a No. 1405 Corbin, bronze-metal sash-bolt, with three strikes. [For ventilation.]

All double-hung sashes in third story and in rear portion of first story are to be trimmed with Ives, No. 150 stamped-bronze sash-locks (Fitch lock, No. 22, Sargent's No. T354a), and wrought, bronze-metal, hook, sash-lifts, two to each lower sash 30 inches wide and over, and one on all others.

(Willer sash-lifts or sash-sockets are to be put on upper sashes.)

Stop-Beads. All stop-beads of double-hung windows in first and second stories are to be secured with a window-stop adjuster finished to match the other hardware of the room and spaced about 12 inches apart.

Doors Under Windows. Where there are doors below the sashes they are to be hung with 3 by 3-inch light loose-pin, solid-bronze butts, ball-tipped. One 4-inch bronze-metal, square-cased bolt (or 4-inch bronze-metal, flush bolt) is to be provided for each one of these doors, and is to go into the sill. There is to be one 2-inch real-bronze cupboard-turn at the center, and a flush-lift-and-lock combined, in bronze-metal (Yale & Towne, No. GL11349), to go on the lower sash.

Casement-Windows. The casement-windows in the second story are to be hung with 3 by 3-inch light, loose-pin, solid-bronze butts, ball-tipped and fitted with (Russell & Erwin) casement-adjusters (No. 20, 15-inch) or with Corbin casement-fastener, No. 02161½ (Russell & Erwin, No. 11½) or with Yale & Towne Cremorne bolt, No. 160, plain, natural-bronze finish.

Pivoted Sash. Sashes which are pivoted at the top and bottom are to be fitted with Yale sash-centers, No. 1335 and Yale sash-adjusters No. 215, 15-inch.

Cupboard-Trimmings. The swinging sash-doors in butler's pantry are to be fitted with (Stanley) 2½-inch loose-pin light, narrow butts, ball-tipped, bronze-plated and polished, two (three) to a door; 1¾-inch bronze-metal

cupboard-turns and Yale standard, mortise dead-lock, No. 265, (or Yale cupboard-lock, No. 5503). The sliding doors are to be fitted with one bronze-metal flush pull, 1¼ by 3 inches, on each door (and Yale lock, No. 543).

The cupboard-doors below counter-shelf are to be fitted with (Stanley, No. 297) 2-inch loose-pin, light, narrow butts, ball-tipped, polished and bronzed, and 2-inch bronze cupboard-turns, with anti-friction strikes. The standing-leaf of double doors is to have a bronze elbow-catch on the back.

The sash-doors and cupboard-doors in cedar closet and linen-closet are to be trimmed as specified for the doors in butler's pantry, without the lock. All are to be in natural-bronze finish.

The cupboard-doors in the kitchen-pantry are to be hung with 2-inch narrow, japanned butts, and trimmed with 2-inch bronze-plated (Boston finish) cupboard-catches, with elbow-catch for standing-leaf.

Medicine-Closet. The door of medicine-closet is to be trimmed with 2¼-inch light, solid-bronze butts, ball-tipped and (Corbin, No. 025 lock with escutcheon-plate No. 2560).

Drawers. The drawers in butler's pantry, cedar closet and linen-closet are to be fitted with 1½ by 3½-inch solid-bronze drawer-pulls, Corbin pattern, No. 2106, two on each drawer 24 or more inches in length, and one on the others.

Two drawers in butler's pantry are to be fitted with Yale "Paracentric" locks, No. 5553. All other drawers are to be fitted with 4-inch square-rim, figured-iron drawer-pulls, No. 3 finish, two on each drawer 28 or more inches in length, and one on the others.

Clothes-Hooks. The bedroom closets and the closet opening from the rear hall are to be fitted with japanned, double, cast-iron clothes-hooks, set 9 inches apart, all around the closet.

The closet under the front stairs is to have twelve bronze clothes-hooks (similar to Yale & Towne hook, No. 456), and four coat-and-hat-hooks (similar to Yale & Towne hook, No. 416).

[The hardware for storm-windows, screens, outside blinds, etc., is usually specified in connection with the fixtures (see Arts. 502 and 504), but if it is not there specified it should be specified here.]

8. HEAVY FRAMING.* CARPENTERS' WORK.

582. Explanation. The following specification-form is offered as a guide in specifying heavy framing; but as buildings of this class vary greatly in the character of their construction, only those features which are generally common to all, are mentioned. All special features should be carefully shown by scale drawings and details, and further described in the specifications.

The building hereinafter considered is a three-story brick building with the floors of mill-construction, with wooden posts and with a trussed roof over the third story. The roof has a pitch on each

* See Chap. VII, Arts. 475 to 487.

side of 5 inches to the foot, and is covered with roll or standing-seam steel roofing. At one corner of the building is an octagon tower, terminating in an open belfry. All ironwork is to be included in the carpenters' contract.

[General Conditions. (As in Art. 489.)]

583. Additional General Conditions. All timbers, furring-stock, iron plates, steel beams, hangers, joint-bolts, truss-rods and all ironwork and hardware of every sort for the floors, roofs, trusses and belfry, and wherever necessary or required throughout the entire work, as shown or as may be shown, by the working drawings and the specifications thereon written, are to be furnished by the carpenter. The several parts of the work are to be framed, raised and fixed in position.

Every steel beam and all metalwork is to be painted one good coat of red lead and linseed-oil (—— graphite paint) before it is set in position, and all hangers, post-caps, anchors, etc., are to be dipped in the same kind of paint.

584. Timber. All posts, planks for girders, floor-joists, truss-timbers and purlins, and all special timbers marked H. P. (hard pine) on framing-plans are to be of the best quality, straight-grained, long-leaf yellow pine (Douglas fir), thoroughly seasoned, sawed full and square to dimensions (and surfaced on four sides; and the timbers when surfaced are to be within ⅜ of an inch of the sizes marked on the framing-plans).

All other framing-timbers, including rafters, are to be of the best-quality, straight-grained (Eastern) spruce (long-leaf yellow pine, Douglas fir), full and square to the dimensions marked on the drawings.

All timbers are to be framed and put together in a skillful manner, according to the plans, sections and details and these specifications.

The posts in the first and second stories are to have 1 by 1-inch chamfers on the angles, stopped 12 inches above the floor and 4 inches below the iron caps. All other timbers are to have square edges.

The basement-posts are to rest on steel post-bases or cast-iron base-plates, made as per detail-drawings and bedded in cement mortar by the stone-mason. The carpenter is to see that they are set true and level.

Cast-iron caps (or steel or malleable-iron post-caps of approved design (see Art. 459, "Post-Caps," Chap. VII) are to be furnished for all posts, and bolted to the posts and girders as shown. Each upper post is to rest on the cap of the post below and not on the girder.

The steel beams for basement-girders are to be furnished, of the sizes and weights indicated, and 3 by 14-inch planks are to be fitted to the sides of the beams and secured by ¾-inch bolts, placed 20 inches on centers.

The girders supporting the second and third floors are to be solid timbers.

The ends of all girders are to rest on approved, steel, wall-hangers (wall-boxes or wall-plates) and in no case are they to rest on steel, stirrup wall-hangers.

All floor-beams and girders are to be framed with top surfaces flush, the beams resting on approved hangers. The wall ends are to hang in approved wall-hangers or rest in wall-boxes or wall-plates of the required dimensions and are to have the wall-ends cut to a 4-inch bevel. The inner ends of the

beams are to hang in hangers of the ——— type or in steel-hangers or stirrups of the required sizes.

The staircase-opening is to be framed around with headers and trimmers of the size shown, hung in (the same kind) of hangers. The tail-beams are to be secured as specified above; the header is to be secured to the trimmers by ¾-inch round-iron dogs, 16 inches long, turned down 2 inches into the wood. Three-inch long-leaf yellow pine (Douglas fir) planks of the same depth as that of the beams are to be framed between the floor-beams against the side walls to receive the underfloor; these pieces are to hang in 3-inch joist-hangers.

585. **Roof-Trusses.** The roof-trusses are to be constructed as shown on the scale and detail drawings. All rods are to be of medium steel, upset without welding, and each rod is to have a head on one end and a square nut on the other. All bolts, nuts, plates and washers shown on the drawings are to be put in, and the timbers are to be fitted to make tight joints with even bearings. Timbers are to be raised and fixed in position in the most careful manner to guard against accidents. The trusses are to be crowned 1½ inches in the center.

The trusses are to rest on cast-iron plates, made as per detail drawings and carefully bedded in cement on the brickwork. The trusses are to be braced from the walls with wooden braces bolted to the trusses, and to 6 by 10-inch uprights set against wall, and resting on stone corbels. These uprights are to be bolted to the walls with three ¾-inch bolts 22 inches long, furnished with 6 by 6 by ¼-inch plate-washers on the wall ends.

The purlins are to be framed as shown on sections and roof-plans. The two outer rows are to be supported from the trusses by 6 by 8-inch posts, capped with 6 by 8 by 30-inch bolsters. The bolsters are to be secured to tops of the posts by two ¾ by 12-inch square drift-bolts, driven in ¾-inch round holes, and are to be bolted to the purlins with one ¾-inch bolt in each end. The bottom of each post is to be secured and the posts are to be braced from the trusses as shown; the purlins, also, are to be braced from the posts with 6 by 6-inch braces, gained into the posts and purlins ½ an inch and secured with ¾ by 8-inch lag-screws.

The other purlins are to be hung from the top chord of the trusses on 3½ by ⅜-inch double stirrup-irons and are to be tied together with ¾-inch round-iron dogs, 32 inches in length and turned down into the timber 1½ inches.

The ends of all purlins are to be tied to the walls with ¾-inch iron anchors, passed through the walls and secured with 5-inch star-washers (ornamental wrought-iron washers) and nuts on the outer ends. The inner ends are to be flattened and spiked to the sides of the purlins with three twenty-penny spikes.

A wall-plate made of two 2 by 12-inch long-leaf yellow pine (Douglas fir) planks, is to be bolted on top of the side walls and laid so as to break joints and to form a continuous tie from end to end (or around the building, if there is a hip-roof). The plate is to be secured to the wall with ¾-inch (⅞-inch bolts, 20 inches long, each with a 4 by 4 by ¼-inch plate-washer on the lower end. The bolts are to be spaced (6 feet) apart. A 2 by 12-inch plank is to be

boted on top of the gable-walls with ¾-inch bolts and 6-inch washers, set 8 feet apart on the rake. The top of the plank is to be on a line with the top of the rafters.

The rafters are to be framed on the plate and purlins as shown on the section-drawings, and secured by fortypenny spikes. The ends of rafters where they lap are to be spiked together. The outer ends of rafters are to project (20 inches) beyond the plate and are to be cut for the cornice as shown.

586. Belfry-Framing. The belfry is to be framed as per framing-plans and as herein indicated. A plate, formed of two 2 by 12-inch long-leaf yellow pine (Douglas fir) planks, is to be bolted to the walls, lapped at the angles and secured to the brickwork at each angle with ¾-inch bolts, 5 feet long, and at the center of each side with ¾-inch bolts, 30 inches long. The bolts are to have 6 by 6 by ¼-inch washers on lower ends.

The belfry-posts are to be turned from 10 by 10-inch cypress (cedar, redwood) stock, (16 feet long). They are to rest on the wall-plates and are to be secured to them by 2½ by ⅜-inch angle-straps, bolted to the plates and to each side of the posts with ¾-inch bolts. The bolts through the posts are to be 12 inches above the plates.

Between the posts, at the height shown, are to be cut 4 by 10-inch timbers, secured to the posts with fortypenny spikes and one ½ by 6-inch lag-screw in each end of each stick. Braces are to be put from posts to plates and the spaces between the plates and the 4 by10-inch timbers are to be filled in with 2 by 6-inch studs set (10 inches) on centers.

A 4 by 10-inch plate, halved at the angles is to be bolted to the top of posts with ¾-inch joint-bolts, 16 inches long, one bolt in each post. The space between this plate and the roof-plate is to be filled in with 6 by 6-inch corner-posts, 2 by 6-inch studding and 2 by 6-inch braces, as shown. The roof-plate is to be tied to the posts and the posts to the lower plate with 1½ by ¼-inch iron straps, 12 inches long, with two sixtypenny spikes in each end.

The roof of belfry is to be framed as shown on the framing-plans and sections, and the hips are to be cut against an 8-inch pole at the center. The pole is to be octagonal in cross-section and is to be carried down and spiked to the ceiling-joists. A level ceiling is to be formed with 2 by 6-inch joists, spaced 20 inches on centers, and spiked to the plates and rafters.

Lookouts. Plank lookouts are to be furnished the mason who is to build them into the gable-walls 22 inches on centers, and set them true in line for the cornice and belt.

587. Underfloors. An underfloor is to be laid throughout the first, second and third stories, of (3-inch) spruce (native pine, Douglas fir) planks, not over 9 inches wide, dressed on one side to a uniform thickness of not less than 2¾ inches and grooved on both edges for long-leaf yellow pine ¾ by 1½-inch splines. The planks are to be laid diagonally on the joists, blind-nailed over every bearing with tenpenny nails before the splines are driven in, and all end-joints are to be cut over the center of the joists or close against the walls or flush with the joists at the openings.

588. Partitions. The partitions are to be built of 2-inch steel channels, with expanded-metal on both sides, put up under another contract. The

carpenter is to cut 2 by 3-inch sole-pieces between the studs and spike them to the underfloor, set up a 2 by 2-inch rough frame around the door and window-openings and secure it to the steel studding with screws. He is to furnish, also, 2 by 2-inch wood furring blocks, as many as may be necessary to secure the finish; these blocks are to be attached to the partitions by the contractor therefor.

[Windows, wood lintels, etc., as for any brick building.]

9. STORE-FRONTS.

589. General Conditions.* *First Method.* The store-front is to be constructed as shown on the scale and detail drawings. All exposed woodwork is to be of clear, white pine (quartered white oak, cypress, redwood or white-wood).

The sashes are to be 2¼ inches thick, molded, rebated for the glass and properly secured. The sill is to be 2¾ inches thick with outer edge molded as per full-size section, and bored for ventilation. The transom-bar is to be molded out of (3 by 4-inch) stock and finished with one row of dentils. The door-posts are to be worked out of solid timber † (5 by 5 inches) rebated for the door and transom and headed on the outer edges. The transom-sash is to be hung at the top and fitted with transom-lifters as specified elsewhere.

The doors are to be (2⅛ inches) thick (veneered with quarter-sawed oak on a staved-up white pine core), made in the best manner, of kiln-dried stock, divided into panels as shown, with raised panels at the bottom and raised (flush) panel-molds around both wood and glass panels.

The molded panels are to be formed below the sill and finished with a 1⅛-inch molded base, scribed at the bottom, or a 2¼-inch rebated plank frame is to be made for the basement-sashes below the main sill, with (1¾-inch) rebated sills (grooved for the back of the iron sidewalk), and with a ¾ by ⅞-inch molding broken around the frame). The basement sashes are to be (1¾ inches) thick, divided into lights as shown, hung at the top with 3-inch heavy, narrow, japanned butts, and provided with 2½-inch brass cupboard-catch at the bottom, and with galvanized hook-and-eye to keep them open. The openings are to be covered with wire guards made of No. 11 wire, 1¼-inch mesh, with ⅜-inch round-iron frame, all painted with black varnish.

A false beam is to be formed above the sash around entrance, and the ceiling of entrance is to be formed with (⅞ by 2½-inch) beaded ceiling with ⅞ by 2½-inch bed-molds.

The platforms inside are to be formed of ⅞ by 2½-inch (⅞ by 4-inch) tongued-and-grooved, quartered, white oak (maple, long-leaf yellow pine) flooring, blind-nailed to (2 by 4-inch) joists, set 16 inches on centers, and carefully smoothed and scraped. A molded nosing is to be formed on the inside with ⅞ by 3½-inch molded apron under, and matched and beaded ceiling is to be put on (or molded panels formed) from the apron to the floor.

* The type of store-front construction here specified is now little used except in the cheaper forms of construction. For a description of the modern types of store-front construction, see Art. 153, Chap. III, and the catalogues of the various manufacturers.

† If the store-front is finished in hardwood, the posts should be of white pine, veneered with ½-inch stuff.

Glass. The small sashes to light the basement are to be glazed with first-quality (AA) double-thick glass, set in putty. All other glass in the store-front, including the door-lights, is to be of polished plate glass, secured in place with stop-beads (screwed on with nickel-plated screws).

590. **General Conditions.*** *Second Method.* The frame for the store-front is to be constructed as shown on the scale and detail drawings. The angle-posts, transoms and division bars are to be worked out of solid, clear, straight-grained, well-seasoned white pine or redwood, molded as per details and rebated for the glass. The sill is to be molded out of 3 by 8-inch (redwood, cypress) and strongly supported. The door-posts are to be worked out of 4 by 4-inch whitewood (cypress), rebated for the door and transom and beaded on the outer edges.

The outsides of angle and division-bars are to be covered with oxidized-copper sash-bars (copper sash-bars, nickel-plated) of the size and shape indicated on the drawings and formed over white pine (redwood, cypress) cores. The vertical bars are to be cut in between the sill and transom and between the transom and soffit of window. A 1⅛-inch plank is to be put up at the top and sides, secured to the ironwork by machine-screws, and veneered with ½-inch (whitewood). A 1 by ¾-inch oxidized-copper sash-bar, made to cope with the vertical bars and to fit against the iron soffit and columns is to be used for covering on outside.

All metal sash-bars are to be put on with (2½-inch) round-headed screws, set about 16 inches apart, and finished to match the sash-bars.

[The other parts of the window, the doors, glass, etc., are to be same as specified above.]

10. PAINTERS' WORK.†

591. **Subject of the Specification.** The following specifications are for the painting, enameling, staining and finishing of woods generally in an ordinary and also in a first-class manner, and also for the painting of brick, plaster, cement, concrete, iron, etc. Special attention is called to the numbered notes following the specifications for detailed information.

592. **Painting New Exterior Woodwork.** *Ordinary Work.* All knots, rosin and sap-portions are to be properly shellaced. One coat of white priming is to be brushed well into the wood, after which all nail-holes, open joints and other imperfections are to be closed solid with putty containing 20 per cent. of white lead; two coats of paint of the color desired are then to be applied. Each coat is to be thoroughly dry before another is applied. The backs of all window and door-frames are to be painted one coat be-

* If the store-front is to be constructed as in Fig. 214 details D, E and F, it should be specified as in this article.

† These specifications and notes on "Painters' Work" have been adapted from "Architectural Specifications for the Painting, Enameling, Staining and Finishing of Woods and for the Painting of Brick, Plaster, Cement, Concrete, Iron, etc.," by John Dewar, Pittsburg, Pa., by permission of the author.

They are suggestions for additions and interpolations for architects' specifications for painting, oiling, varnishing, etc., and contain much valuable information.

fore setting. Sash-runners of window-frames are to receive two coats of oil, stained if required, and the last coat is to be applied at completion. No paint is to be applied during wet or foggy weather. [See Note 1, Art. 618.]

First-Class Work. Woodwork is to be painted as above specified, adding one additional coat. [See Note 1, Art. 618.]

593. **Repainting Exterior Woodwork.** The removal of such old paint from exterior woodwork as may be necessary is to be done by scraping, burning or paint-remover, as conditions may require. All that portion from which the old paint has been removed is to be sandpapered and touched up with one or two coats of paint according to the necessities of the case. All woodwork is to be painted with two coats; colors to be selected. All necessary sandpapering and puttying is to be done. [See Note 2, Art. 619.]

594. **Staining Exterior Woodwork.** *Ordinary Work.* All exterior woodwork (or a part of it, as the case may be) is to receive one coat of linseed-oil stain, brushed thoroughly and uniformly into the wood. The color is to be as required. The pigments are to be selected for their permanency of color. The vehicle is to consist of 40 per cent of 160-degree benzole and 60 per cent of raw linseed-oil. All nail-holes and other imperfections are to be closed with lead-putty, colored to match the stain, and then one good coat of raw linseed-oil containing 10 per cent of turpentine is to be applied. [See Note 3, Art. 620.]

First-Class Work. One additional coat of oil containing 10 per cent of turpentine is to be specified. [See Note 3, Art. 620.]

595. **Staining Shingles.** Shingles are to be dipped to two-thirds of their length into the stain specified above; color to be as determined. After the shingles are in position they are to be touched up, and one coat of linseed-oil containing 10 per cent of turpentine is to be applied. [See Note 3, Art. 620.]

596. **Restaining Exterior Woodwork.** All of (or such portions of) the exterior woodwork that requires treatment is to be properly prepared, and restained a color that conforms closely to the original stain. All stained woodwork is to be coated with two coats of linseed-oil containing 10 per cent of turpentine. Before the second coat is applied all imperfections are to be closed up with putty colored to match the stain. [See Note 4, Art. 621.]

597. **Painting New Exterior Brickwork.** All new exterior brickwork is to be painted two good coats of Venetian red containing about 20 per cent of white lead. The vehicle is to consist of 80 per cent of linseed-oil and 20 per cent of turpentine. After these coats have been applied, one coat of flat, brick-colored paint of the desired shade is to be applied. Care must be exercised to cover thoroughly and to "cut in" neatly each "stretch" of work so as to produce a uniform, flat surface. This coat must not be worked too thin. [See Note 5, Art. 622.]

598. **Repainting Old Exterior Brickwork.** All open joints and other imperfections are to be closed up. All such places, including any portion from which the paint has been badly worn, are to be touched up. All exterior brickwork is to be painted one coat of Venetian red containing about 20 per cent of white lead. The vehicle is to consist of 80 per cent of linseed-oil and 20 per cent of pure turpentine. After this, one coat of flat,

brick-colored paint of the desired shade is to be applied. Care must be exercised to cover thoroughly and to "cut in" neatly each "stretch" of work so as to produce a uniform, flat surface. This coat must not be worked too thin. [See Notes 5 and 6, Arts. 622 and 623.]

599. **Painting New Exterior Plaster, Cement and Concréte.** All cracks and other surface-imperfections are to be prepared and closed up with plaster or cement. A *thorough* coat of "basic coater" is to be applied to all surfaces, allowing twenty-four hours for drying. After this, three coats of paint of the desired color are to be applied. Each coat is to be thoroughly dry before the application of another. The plaster or cement is to be thoroughly dry before it is painted. [See Note 7, Art. 624.]

600. **Repainting Old Exterior Plaster, Cement and Concrete.** Old paint is to be scraped off when necessary. All cracks and other surface-imperfections are to be closed up with plaster or cement. A good coat of "basic coater" is to be applied over all new cement or plaster, allowing twenty-four hours for drying. After this, two coats of paint of the color desired are to be applied. Each coat is to be thoroughly dry before another is applied. The plaster or cement is to be thoroughly dry before it is painted. [See Note 7, Art. 624.]

601. **Painting New Exterior Iron and Steel.** *Ordinary Work.* All ironwork is to be gone over carefully before it is painted and any dirt or corroded material is to be removed with steel brushes. All ironwork is to be painted with one coat of pure red-lead paint, the vehicle of which is to consist of 80 per cent of raw linseed-oil and 20 per cent of turpentine. After this, two coats of paint are to be applied, consisting of pure lampblack with the addition of a small quantity of Prussian blue and a mixture of about 90 per cent of linseed-oil and 10 per cent of turpentine. Each coat is to be thoroughly dry before another is applied. [See Note 9, Art. 626.]

First-Class Work. All ironwork or steelwork is to be gone over carefully before it is painted and any dirt or corroded material is to be removed with steel brushes. All ironwork is to be painted with one coat of "Kardite Chromatized Red Lead," mixed "on the job," with the proportions of 25 pounds of this material to one gallon of pure linseed-oil; or it is to be painted with "Kardite Red Rust-Inhibitive Paint," and followed by two coats of pure lampblack, mixed with "Flexible Compound," or pure linseed-oil, and with any pigment necessary to produce any desired color. In using "Flexible Compound" as a vehicle no *turpentine nor dryer* is to be used. Each coat is to be thoroughly dry before another is applied. [See Note 8, Art. 625.]

602. **Repainting Exterior Iron Fences, etc.** All loose paint and corroded material is to be removed by scraping and steel brushes. All that portion from which the paint has been removed is to be touched up with pure red lead. All surfaces are to be painted two coats of pure lampblack, to which has been added a small quantity of Prussian blue and "Flexible Compound." Each coat is to be thoroughly dry before another is applied. No turpentine or dryer is to be used in this compound. [See Notes 8 and 9, Arts. 625 and 626.]

603. **Painting Exterior Galvanized Iron.** All galvanized-iron work

is to receive one thorough coat of a solution made by dissolving 6 ounces of copper-acetate in one gallon of warm water. This preparation is to be thoroughly brushed on. When dry, one coat of pure red lead mixed with 50 per cent of linseed-oil and 50 per cent of turpentine is to be applied. This is to be followed by two coats of paint of the desired color. [See Note 10, Art. 627.]

604. Painting Copper. All copper surfaces are to be thoroughly sponged off with 160-degree benzole, after which one coat of pure red lead mixed with 50 per cent of linseed-oil and 50 per cent of turpentine is to be applied and well rubbed out. Two coats of paint of the desired color is then to be applied. [See Note 11, Art. 628.]

605. Painting Tin. All rosin and all imperfections are to be removed. As soon as practicable all tinwork is to be painted one coat of pure red lead mixed with 60 per cent of raw linseed-oil and 40 per cent of turpentine. After this one coat of Venetian red or metallic brown, mixed in pure boiled oil, is to be applied. [See Note 12, Art. 629.]

606. Plain Painting for New Interior Woodwork. All knots and sap-wood are to be shellaced. All woodwork (location to be mentioned here) is to be painted three good coats of the desired color. After the first or priming-coat is put on, all nail-holes and other imperfections are to be closed up with lead putty. All necessary sandpapering between the coats is to be done. [See Note 13, Art. 630.]

607. Painting and Graining New Interior Woodwork. All knots and sap-wood are to be shellaced. All woodwork (location to be mentioned) is to be painted two coats, and no oil is to be used in this paint other than that in which the lead is ground. In mixing, a small quantity of a good mixing-varnish is to be used, and it is to be thinned with turpentine so that the paint will dry with a flat, "egg-shell" gloss. Each coat is to be sandpapered perfectly smooth.

The graining is to be done in the best manner in imitation of the hardwood selected, and the graining-color is to be used as "flat" as possible, consistent with its "working out." All grained work is to be varnished with one coat of a good-wearing body-varnish. [See Note 14, Art. 631.]

608. Natural Finish for New Interior Softwoods. All woodwork is to be thoroughly gone over, cleaned up and sandpapered where necessary, after which one coat of white shellac and two coats of a good-wearing body-varnish are to be applied. The last coat is to be evenly "flowed on." After shellacing, all nail-holes and imperfections are to be closed up with putty colored to match the wood. Care is to be taken to rub off any surplus putty. All work is to be thoroughly sandpapered between the applications of the coats. [See Note 15, Art. 632.]

609. Staining and Varnishing New Interior Softwoods. All woodwork is to receive one light coat composed of 25 per cent of linseed-oil and 75 per cent of turpentine and is to be sandpapered and stained in best manner with an oil-stain containing about 50 per cent of turpentine colored as desired. All nail-holes and imperfections are to be closed up with lead-putty colored to match the stain. Care is to be taken to wipe off any surplus putty-marks. All stained work is to be varnished with two good coats

of a strong-wearing body-varnish. The last coat is to be evenly "flowed on." All work is to be thoroughly sandpapered between the applications of the coats and each coat is to be thoroughly dry before another is put on. [See Note 16, Art. 633.]

610. Painting and Enameling New Interior Woodwork. *Ordinary Work.* All woodwork (location to be mentioned) is to be gone over carefully. All knots and sap-portions are to be shellaced. The priming is to be done with one thin coat of white paint, well brushed into the wood, after which the work is to be thoroughly sandpapered. All nail-holes and imperfections are to be closed up with lead-putty. One light coat of pure grain-alcohol white shellac is to be applied. This coat is to be sandpapered lightly. Three coats of white paint, consisting of about 60 per cent of white lead and 40 per cent of zinc-oxide, and one coat of straight, pure zinc-oxide are then to be applied, followed by one coat of the best enamel, freely and evenly put on. All coats are to be colored as required. Each coat is to be thoroughly dry and well sandpapered before another is applied. [See Note 17, Art. 634.]

First-Class Work. One additional coat is to be added to the above specification (making *four* coats) after the shellac, and these are to be followed by the straight zinc and with *two* coats of best enamel. The last coat of enamel is to be evenly rubbed with water and powdered pumice-stone to a satin or china-gloss finish. [See Notes 17 and 18, Art. 635.]

611. Painting New Plaster or Cement with Distemper-Colors or Calcimine. All cracks and other imperfections are to be closed up with plaster or cement. After this, one full coat of "basic coater" is to be applied and well brushed in, and twenty-four hours allowed for drying. One medium or light coat of paint is then to be applied as a size, consisting of at least 50 per cent of linseed-oil. This is to be followed, when dry, by one "full," free-and-even coat of calcimine or prepared distemper-paint. If one coat of distemper-paint does not produce a "solid" surface, one additional coat is to be given. All surrounding woodwork, etc., is to be thoroughly protected. [See Note 19, Art. 636.]

612. Painting and Varnishing New Interior Plaster and Cement Surfaces. *Ordinary Work.* All cracks and other imperfections are to be closed up with plaster or cement. One full coat of "basic coater" is to be applied to all plaster or cement surfaces and well brushed in, and twenty-four hours allowed for drying. After this, three coats of paint of the desired color, are to be applied. Then one "full" coat of a good-wearing varnish is to be applied. Each coat is to be perfectly dry before another is put on. [See Note 20, Art. 637.]

First-Class Work. All surfaces are to be sandpapered and all cracks or other imperfections are to be closed up with plaster or cement. One "full" coat of "basic coater" is to be applied and well brushed in, and twenty-four hours allowed for drying. After this, all surfaces are to be painted with four coats, colored as desired. The paint is to be composed of 60 per cent of white lead and 40 per cent of pure zinc-oxide. The first of these four coats is to contain about 50 per cent of oil, 10 per cent of a good-mixing varnish and 40 per cent of turpentine; and the three subsequent coats are to

contain about 30 per cent of oil, 20 per cent of varnish and 50 per cent of turpentine. The last coat is to be lightly and evenly stippled. Each coat is to be thoroughly dry before another is applied. [See Notes 7 and 21, Arts. 624 and 638.]

613. Varnishing and Finishing Hardwoods. *Ordinary Work.* All surface-defects are to be sandpapered and removed, stain applied if desired, and the filling done with the best paste filler of the required color. The surface and moldings are to be thoroughly cleaned. One coat of shellac and two coats of a good varnish suitable for this purpose are then to be applied. After the shellac-coat, all nail-holes and imperfections are to be closed up with lead-putty, colored as required, and all surplus putty is to be carefully wiped off. The work is to be sandpapered between the application of the coats. Care is to be taken during the varnishing to keep the premises as free from dust as possible. [See Note 22, Art. 639.]

First-Class Work. All surface-defects are to be sandpapered and removed. Stain is to be applied if required. The filling is to be done with the best paste-filler, colored if necessary. All surfaces and moldings are to be thoroughly cleaned. One coat of pure grain-alcohol shellac and four coats of a first-class varnish designed for this class of work are then applied. All varnished surfaces are to be rubbed with oil and pumice-stone until they are true and even and have a dull satin-finish. All oil and pumice-stone are to be thoroughly cleaned from the surfaces. Each coat is to be thoroughly dry and sandpapered before another is applied. Care is to be taken during the varnishing to keep the premises as free from dust as possible. [See Note 23, Art. 640.]

614. Staining and Waxing Hardwoods. *Ordinary Work.* All work is to be stained with an approved stain, colored as desired. All necessary sandpapering is to be done, after which one coat of paste-filler, colored to match the stain, is to be applied. All surfaces are to be thoroughly cleaned and one medium coat of shellac is to be applied. All work is then to be sandpapered lightly and one good coat of an approved finishing-wax is to be applied. This is to be permitted to stand until it has become partly hardened and is then to be thoroughly rubbed and polished until it becomes a hard surface. [See Note 24, Art. 641.]

First-Class Work. All surfaces (location to be mentioned) are to be coated with one light coat of clean water (this for oak only). When thoroughly dry, the work is to be sandpapered to a perfectly smooth finish, after which it is to be stained uniformly and in the best manner with an approved water-stain of the desired color. It is then to be sandpapered lightly and filled with a paste-filler, colored to match the stain. One coat of pure grain-alcohol shellac is to be applied and sandpapered lightly, after which two coats of an approved finishing-wax are to be applied, three days being allowed between coats. Each coat is to become partly hardened and then thoroughly rubbed and polished until it is a hard surface. [See Note 25, Art. 642.]

615. Finishing Pine Floors. The floors are to be thoroughly cleaned and all surface-imperfections removed. One coat of shellac and two coats of a good varnish designed for this purpose are then to be applied. Each coat is to be thoroughly dry before another is put on. All necessary care

is to be taken to protect this work from damage. [See Note 26, Art. 643.]

616. **Varnish-Finish for Hardwood Floors.** The floors are to be thoroughly cleaned and all surface-imperfections removed. All woodwork is to be filled with a good paste filler which is to be cleaned thoroughly from the surface. Stain is to be applied if required. One coat of shellac and two coats of best varnish designed for floor-use are then to be applied. Each coat is to be thoroughly dry before another is put on. Care is to be taken to protect the floors from damage. [See Note 27, Art. 644.]

617. **Wax-Finish for Hardwood Floors.** The floors are to be thoroughly cleaned and all surface-imperfections removed. The wood-surface is to be filled with one coat of the best paste-filler which is to be thoroughly cleansed from the surface when partly dry. Stain is to be applied if required. One thin, even coat of pure grain-alcohol shellac is to be applied. The work is then to be sandpapered lightly without showing "laps," after which two coats of the best "Prepared Floor-wax" is to be applied, allowing two or three days between the coats. Each coat is to be thoroughly rubbed until it makes a hard, dry surface. Care is to be taken to protect the floors from damage. [See Note 28, Art. 645.]

11. NOTES ON PAINTING SPECIFICATIONS.*

618. **Note 1.** *Painting New Exterior Woodwork.* All authorities seem to agree that pure, raw linseed-oil and pure spirits of turpentine are the best vehicles for paints used for outside work. The vehicle of the first or priming-coat on new wood, and also of the second coat, should consist of 80 per cent of pure, raw linseed-oil and 20 per cent of pure spirits of turpentine, while the final coat should consist of 90 per cent of pure, raw linseed-oil and 10 per cent of pure spirits of turpentine. All the coats should contain the necessary "driers." When four coats are used, the first, second and third should be composed of 80 per cent of oil and 20 per cent turpentine, and the fourth of 90 per cent of oil and 10 per cent of turpentine.

There exists some diversity of opinion as to the best paint-pigment or paint-pigments in combination. It is very necessary that the composition of a paint-film be as near perfect as possible. The necessity for this is apparent from this fact: "the average paint-coating is only three one-thousanths of an inch thick, and yet this thin coating is required to withstand the expansion and contraction of the underlying surface, the abrasion or wear from storms of dust and sand, or from rain, sleet, hail, the absorbing, drawing and expanding influences of the summer's sun and the contraction from the cold of winter. It must be hard enough to withstand to a reasonable extent this surface-wear, and at the same time be elastic enough to meet internal stresses and to conform to changes in the underlying surface; it must also penetrate and cling to the surface to which it is applied. It must also prevent or retard moisture and atmospheric gases, which cause decay, from gaining access to the underlying surface." It must, also, if it has the qualities essential

* See Arts. 592 to 617, inclusive, for applications of the data contained in these notes comprising Arts. 618 to 645.

to a good paint, present in the course of time, when repainting becomes necessary, a suitable foundation for new paint-coatings.

It is a generally accepted fact that a white or tinted base-paint containing about 75 per cent of white lead and 25 per cent of zinc-oxide, is a high-standard paint. When used near or at the seashore, or in the Southern States, it can be improved by changing it so that it will contain 60 per cent of white lead and 40 per cent of zinc-oxide. The reason that these two best paint-pigments are combined is that the one has a tendency to strengthen the weak points of the other, and to make an ideal paint-coating. The zinc makes the film stronger and harder, as well as practically non-absorbent, and by reason of its fine texture, fills up the voids, caused by the coarser pigment. The manufacturer should combine and grind the two pigments together in order to thoroughly amalgamate the two.

When the result required is a white or color-tinted paint, it is advisable to use the same percentage of different basic pigments and coloring-matter in all of the coats, in order to obtain uniform expansion and contraction, solidity of color, etc.

When *"prepared mixed paints"* in paste-form are used, the *limit* of inert pigments should be 15 per cent. This percentage may be composed of barytes, silica or "Asbestine," or a mixture of such pigments. To this amount there should be no objection as up to this limit these "inerts" have their values as parts of a good paint-film; the proportions given for the "vehicles," however, should be followed.

The use of "Asbestine" is principally to hold in suspension the heavier pigments in the paint, its fluffy and rod-like form being valuable for this purpose. Its action as a reinforcing pigment is somewhat analogous to that of the steel bars in the reinforcing of cement or concrete structures.

Straight white lead makes a splendid primer. Neither ochre nor boiled linseed-oil should be used for undercoatings. When the color of the finishing-coat is required to be a strong, solid color, such as green, red, etc., the use of these strong-colored paints from the foundation up will not result in a solidity of body. The use of a strong-tinted, white base, therefore, is suggested for the under-coatings.

In the painting of cypress and southern yellow pine, the vehicle in the priming-coat and *priming-coat only* should be composed of 40 per cent of 160-degree benzole, 10 per cent of pure spirits of turpentine and 50 per cent of pure raw linseed-oil, and the subsequent coats should follow as specified above. The character of these woods is such that paints made with the usual vehicles will not penetrate them. But with the turpentine and the addition of the benzole, which is one of the greatest penetrating solvents of rosin, gums and grease known, the oil and the pigments when well "brushed out," are carried into the wood where they find lodgment and form a substantial and permanent foundation for subsequent coatings. The benzole, like the turpentine, after performing its mission evaporates entirely, leaving no residue.*

The building of a first-class residence or other important operation, frequently requires a year or more. An additional or fourth coat of paint

* See "Modern Lumber as a Problem for the Painter," by John Dewar,

is, therefore, a necessity. The following distribution is recommended for these four coats. After the priming or first coat and the necessary puttying, the second coat should be applied. The third and fourth coats should be put on about the time of the completion of the building. One reason for the application of a fourth coat is that the owner of the building, impressed with the fact that he has a *new* residence, is usually careless regarding the necessity for repainting for a term of years.

If the priming-coat is put on when the work is first put in place, and the next two coats about six months or a year later, the work will probably require repainting in less than four years. This would seem to prove the economy of the initial fourth coat, which, under average conditions, acts as a protective agency for probably six or seven years.

619. Note 2. *Repainting Exterior Woodwork.* In the work of repainting so much depends upon the actual conditions that it is practically impossible to intelligently specify without being familiar with them.

The basic-paint pigments should be as specified in Note 1. The proportions of vehicles for the first coat must be determined by the existing conditions. For instance, if the vehicles of the old paint-coatings are dried out, leaving an absorbent surface, the vehicle for the first coat should consist of about 75 per cent of raw linseed-oil and 25 per cent of turpentine, and the second or final coat of 90 per cent of raw linseed-oil and 10 per cent of turpentine. Or, if the surface is hard and non-absorbent, the proper proportions of the vehicle for the first coat should be about 50 per cent of oil and 50 per cent of turpentine, and for the final coat, 90 per cent of oil and 10 per cent of turpentine. Not infrequently, from a number of causes, it has been found necessary, in repainting, to paint all of the woodwork with three coats.

To overcome imperfect conditions and to obtain the best results requires good judgment as well as good materials. The best results often depend rather upon the proportions of the vehicle than upon the pigments themselves.

The "paint-burner" should not be used if it can be avoided. In case it is used, the owner of the building should consent to its employment, notify his insurance company and get a permit from them consenting to its use.

620. Note 3. *Staining Exterior Woodwork.* This stain is suitable for all kinds of wood used for exterior finish. It must be remembered that a stain implies a transparent coloring and not a paint-coating which is opaque. If it is desired to stain oak or cypress to a dark-green or a dark-brown color, such as is generally used on half-timber work, two coats of stain should be specified to get the necessary depth of color. To attempt this with one coat would result practically in a paint-coating, and would cover or hide the figure of the wood. If it is desired to stain oak silver-grey or any other light color, but one coat is necessary. Shingles, owing to the depth of color required, frequently require a second coat of stain after they are set in place. When benzole is used in the stain, as has been before stated, it becomes the active penetrating factor, carrying the coloring-matter and oil into the woods. It has about the same evaporating-consistency as turpentine.

There being a substantial difference, therefore, between a paint-coating and a stain, the stain specified can be used when necessary for both coats.

Where a perfectly flat surface is desired, the second coat of oil may be an objection; but it is recommended for durability, and also, for the reason that the oil-gloss shortly flattens down.

There are a number of very good shingle-stains on the market.

621. Note 4. *Restaining Exterior Woodwork.* Restaining is also a matter of judgment as to whether the entire work or only a part of it should be gone over with a light coat of stain, when it is in bad condition, and as to whether it should have one or two coats of oil. A careful examination should lead to a wise decision. A coat of oil over the old stain will make quite a difference in the appearance of the old color.

622. Note 5. *Painting New Exterior Brickwork.* If penciling or striping of joints in either white, black or other color should be required, it should be specified after the application of the flat coat, the lines being true to the size of the bricks and uniform in width.

There are a number of paint-manufacturers who make a first-class prepared "flat, brick-color," in red, buff or grey, each consisting of a number of shades, light, medium and dark. They will furnish, also, any required shade or color.

This specification applies to flat, red-brick finish. If a buff or grey, flat brick-color is required, instead of Venetian red, two coats of lead-and-oil paint, colored to conform to the bricks selected, should be specified. When a buff or grey brick-color is desired it should be so stated in the specifications, as a lead-and-zinc-base paint costs considerably more than Venetian red.

For a gloss-finish in red, buff or grey, or any other color, three full coats are required, the final coat containing about 90 per cent of linseed-oil and 10 per cent of turpentine.

623. Note 6. *Repainting Old Exterior Brickwork.* The painter should not be expected to be a brick-mason. If any amount of repointing is necessary, special arrangements should be made for it.

Usually one coat of oil-color is sufficient, but where the surface is badly worn, two coats of an oil-paint are to be applied, as it is practically necessary to have a uniform, gloss-surface before the flat brick-color is put on.

For a bright, gloss-finish on old work in any color or shade, two full coats are to be applied, the final coat containing about 90 per cent of oil and 10 per cent of turpentine.

624. Note 7. *Repainting Old Exterior Plaster, Cement and Concrete.* All practical painters agree that in painting over plaster and cement-surfaces many serious difficulties are encountered and that additional future trouble is probable, because of the free lime and alkali which are a part of the composition of plaster and cement, and which are formed in the drying out of these materials. Their destructive action on colors and paint-vehicles is well known. A necessary requirement of a cement-paint is, that its vehicle and its colors are not impaired when in contact with cement or lime. The results of investigations made during a number of years and of the use of the "Basic Coater," have convinced the writer that this coater is of great value in the preparation of plaster and cement-surfaces for painting, or otherwise embellishing, as it neutralizes these destructive agencies, without

in any way impairing the strength or other useful properties of the cement or lime. In fact, the deterioration of the vehicle and of the colors and the usual objectionable discolorations are prevented when the "Basic Coater" is applied first. It should be freely applied. When dry it acts in a measure as a light sizing-coat over which any paint can be applied with perfect safety.

Another necessary property of a cement-paint is that of resistance to and non-absorption of water and dampness. One hundred per cent of the present-day cement-paints are designed for that purpose. Eighty per cent of them break down soon after use, because of their faulty composition, the use of practically unknown and not thoroughly tried-out vehicles, and the disintegrating action of the alkali in the cement and lime. With the "Basic Coater" there need be no hesitancy in recommending the use of a paint containing the following ingredients: pigments, 70 per cent of white lead and 30 per cent of zinc-oxide; vehicle, 80 per cent of raw linseed-oil and 20 per cent of turpentine; the last coat, 90 per cent of raw linseed-oil and 10 per cent of turpentine, each coat containing one pint of a good gum-mixing varnish to one gallon of paint. The paint must have a good body, be well worked into the surface and each coat must be thoroughly dry before another is applied.

If a semi-flat surface is desired, the quantity of oil in the final coat is to be reduced. There are a number of very good paints found on the market designed for this kind of work, but the use of the "Basic Coater" is recommended in conjunction with them. In the use of a semi-flat coat for a finish, the undercoating is recommended to have a good gloss for the reason that the "flatter" a paint is the greater is its absorbent property. The fact should not be overlooked that the paint under consideration is for use on outside work.

For old brickwork, repointed with cement or lime before repainting, a coat of "Basic Coater" is recommended as it prevents the alkali in the pointing-material from destroying the color of the paint.

No paint should be applied to damp surfaces. Paint-films will not withstand the disintegrating effects of wet foundations.

625. Note 8. *Painting New Exterior Iron and Steel.* Ordinary Work. "Kardite Red Lead" is a chromatized preparation, acting as in inhibitor of corrosion on iron and steel. "Kardite Red Rust Inhibitive Paint" can be purchased mixed ready for application without reduction.*

"Flexible Compound" is a specially prepared oil containing compounds which make it very durable and water-resisting. Turpentine and dryers must not be used in connection with it, but raw, linseed-oil, up to 50 per cent in amount, may be used as a reducer. "Flexible Compound" has been used with much success for structural iron and steel and for iron fencing.

626. Note 9. *Painting New Exterior Iron and Steel.* First-class Work. "Red lead" when pure is of exceptional merit as an iron and steel paint-pigment. For structural work, two coats may be applied. This lead is found to be very much adulterated, especially when purchased in bulk for

* See Bulletin on "The Preservation of Iron and Steel," and other data relating to "Kardite Paint," by Dr. Allerton S. Cushman and Dr. H. A. Gardner, The Institute of Industrial Research, Washington, D. C.

large operations, but it can be obtained pure. For a certain large steel-frame building the specifications read: "all steelwork is to be painted with two coats of 'pure red lead,' one coat to be put on at the mill and the other when the work is assembled." The contractor bought and paid for what he supposed to be "pure red lead." As it had the color of that pigment, he took it for granted that it was the paint specified and ordered by him. When the work was finished, some of the so-called "pure red lead" was taken from the building and found, after an analysis, to contain 60 per cent of red lead and 40 per cent of calcium carbonate (whiting) which is known to be one of the *causes* of corrosion.

During the last year (1912) an improvement in the process employed in the manufacture of red lead has resulted not only in a greater purity of the product, but also in the elimination of its tendency to harden in the packages. This tendency has been a serious drawback in its use.

Lampblack, ground in linseed-oil is also a first-class pigment. For a denser black a small quantity of Prussian blue is added. When this combination is mixed with the "Flexible Compound" the result is a splendid paint for this purpose.

627. Note 10. *Painting Galvanized Iron.* How to effect the adhesion of paint to the surface of galvanized iron has long been a problem for the painter; but it has been practically demonstrated that the preparation specified, if thoroughly applied, will overcome the difficulties. After this solution remains on the metal for 24 hours, it will remove all the grease and other substances which interfere with the proper painting. It will produce a blackened, coppered surface to paint upon, which will readily hold the piant. Other solutions, such as nitric acid and muriatic acid, cause a rusting of the iron surface and interfere with the painting. The use of copper-acetate, however, results differently. Copper-acetate is simply a solution of metallic copper in strong vinegar. It can be made by the painter himself, but it is cheaper if bought at the drug-store and mixed in hot water as specified. It is strongly insisted upon that the first coat of paint be of red lead with about 50 per cent of raw linseed-oil and 50 per cent of turpentine. If the color desired for the finish-coat is dark, one additional coat will be sufficient; but if it is white or a light-tinted color, at least two coats will be required.

628. Note 11. *Painting Copper.* How to make paint adhere to copper surfaces has been quite a problem. The trouble is caused by the oil or grease used to keep the surface of the copper from becoming tarnished or stained while in stock or in transportation. With the removal of these oils by the use of benzole as a cleaner, followed by a hard-drying body of red lead, thus forming a firm foundation for the subsequent paint-coatings, permanent results are secured.

629. Note 12. *Painting Tin.* For new tinwork on roofs, two coats, only, of paint are recommended with an application of one coat every two or three years thereafter. Tin being non-absorbent, the accumulation of paints on its surface, together with its expansion and contraction, soon causes checking and what is called "alligatoring." The snow and rain, also, lying on the surface for an indefinite time, add to the tendencies to deteriorate.

White-lead or graphite-paint should not be applied directly to the new tinwork, but for subsequent coatings there is no objection to them.

630. **Note 13.** *Painting Interior Woodwork.* If the color required is white or a light tint, the woodwork should first receive one coat of shellac to prevent discolorations from rosin and sap-wood. If a varnish-coat is required over the paint, all painted work is to be specified to receive one coat of a good-wearing, light-colored varnish, evenly applied.

631. **Note 14.** *Painting and Graining Interior Woodwork.* If a first-class job is required, one additional coat of varnish, full and evenly applied, is to be specified, each coat being thoroughly dried before another is put on. If a flat finish is required, the last coat of varnish is to be specified to be rubbed evenly to a flat finish with crude oil and pumice-stone, and all oil and pumice-stone thoroughly cleaned off at completion.

A flat finish may be secured by using what is termed a "flat varnish." In the use of a flat varnish, two coats are required, the first being a gloss-varnish. About 50 per cent of these varnishes contain a large percentage of wax, over which paint and varnish cannot be applied at any future time, as neither will adhere permanently to a wax-surface. The use of some of these flat varnishes is commendable, especially to produce certain results on natural hardwoods.

Graining is practically becoming a "lost art," owing to the general use of hardwoods. Where the work is well done this specification should produce excellent results. Painters may not agree on the number of coats and manner of mixing of the ground-coating. It is the opinion of the writer that no cracking or crazing of the varnish will result. Of course the varnish must be good and the undercoating perfectly dry.

The woods best adapted to painting and graining are birch, cherry, maple, poplar and white pine.

632. **Note 15.** *Natural Finish for New Interior Softwoods.* This would apply to white pine, poplar, yellow pine, cypress, etc. Sometimes a flat finish is required; in that case the rubbing with oil and pumice-stone to a dull even finish is to be specified. Close rubbing on two coats of varnish is not recommended as it must be kept in mind that close rubbing will practically remove one coat of varnish. Rubbing of work in servants' quarters and in average, ordinary medium jobs, is not recommended.

The natural color of these woods is sometimes an objection. In that case a "touch" of burnt sienna, or burnt and raw sienna, may be added to the first coat of varnish, not enough to produce a stain, but enough to give the wood a warm, pleasing glow, and to remove the harshness of the natural color.

633. **Note 16.** *Staining and Varnishing New Interior Softwoods.* The reason for applying a thin coat of oil to the woodwork before staining is because certain portions of the surface may be very much softer than others, the differences appearing even as spots over the entire surface. With the application of the oil as specified, the suction of those soft places is, in a measure, stopped, and a practically uniform surface is obtained on which to work the stain. A thin coat of shellac instead of oil might be used; but the oil thinned with the turpentine is preferred, as a more uniform absorp-

tion into the wood is obtained for the stain, the shellac in a measure stopping the absorption.

For a flat surface the rubbing with oil and pumice-stone to a dull finish is specified; for close rubbing one additional coat of varnish is specified. This specification would apply to white and yellow pine, poplar, cypress, etc.

634. **Note 17.** *Painting and Enameling New Interior Woodwork.* With the application of a second coat of enamel the rubbing with water and powdered pumice-stone to a very good finish may be added to this specification. If a semigloss or flat finish is desired with but one coat of enamel, the enamel is to be reduced by mixing into it a portion of the straight zinc-coater necessary to give the condition required. To obtain the best results, without show-laps, brush-marks or cording, requires very careful brushing.

With the exception of the priming-coat no oil should be used except such as may be found in the stiff lead and zinc; the priming-coat should consist of about 40 per cent of oil and 60 per cent of turpentine, light of body and well brushed into the wood. Zinc for enameling-purposes should be ground in poppy-oil, which greatly minimizes the chances of the work turning yellow when confined to a dark room. The use of linseed-oil is one powerful cause of work turning yellow when excluded from a strong light. In the preparation of several under paint-coatings, instead of oil as a binder, a portion of a good-mixing enamel-varnish should be used, each coat being worked flat. In using the straight zinc-oxide for the final coat of paint in this class of work, it is found that purer tints of greater variety can be obtained, with less danger of chemical action than if some white leads are used.

The straight zinc-coat should have an "egg-shell gloss" for the reason that, if it were perfectly flat, as the under paint-coatings should be, it would absorb and draw out the liquid elements from the enamel-coat, leaving a surface of questionable uniformity.

The different coats of paint, from the shellac up, should be tinted as required for the finish; for a "solidity" of tint is thus obtained that could not otherwise be secured. For a perfect white job, the painter is oftentimes said to "draw the lead." That is, the lead is broken up in the turpentine to a thin consistency and permitted to stand twenty-four hours, the surface liquid being then poured off and the remaining lead being practically free from oil. With the percentage of zinc-oxide specified and with the use of a good white enamel-varnish, or what is better, a portion of the enamel as a binder reduced with pure turpentine to a working-consistency, a ground-work for the enamel finish is obtained that cannot be equaled, provided each coat is permitted to become thoroughly dry before another is applied. For a "dead white," the paint is sometimes given a "touch" of blue or black.

If for the finishing-coat an enamel-varnish instead of a "prepared enamel" is specified (and there are a number of good "prepared enamels"), a small portion of the zinc-coat is to be specified to be added to the varnish because there are no good light varnishes made that will not discolor pure white and very delicate tints. A *good enamel* is expensive, but it is worth the money.

The woods adapted for enameling are cherry, birch, maple, poplar and white pine.

635. **Note 18.** *Superior Work in Painting and Enameling.** This specification if faithfully carried out will produce excellent results. For this high-class work cherry, birch, or plain maple should be used; good results can be secured on white pine or poplar.

636. **Note 19.** *Distemper and Calcimine on New Plaster and Cement.* There are quite a number of most excellent distemper-preparations on the market, known by different names. The old-fashioned "calcimine" still maintains a substantial standing, largely owing to the ease with which it can be removed when refinishing becomes necessary. It is true the former is less absorbent, but extremely difficult to remove.

There are a number of very good sizes that could be used for this purpose, but no better one is known than a good coat of oil-paint, white or lightly tinted, and applied directly over the "basic coater." Its useful properties are many; for instance, when about 50 per cent of linseed-oil is used in the paint, and when it is thoroughly dry, it produces a splendid working-surface and also a permanent sizing-surface for future refinishing. The old material can be readily cleansed from it, that is, if the material used will permit of its being removed from anything.

Under no consideration should a varnish-coating be used for sizing-purposes, as it does not permit of any absorption and is extremely hard; in fact, it is impossible to produce an even and uniform surface on a high gloss. There is also a very great tendency for the calcimine to loosen and flake off on account of the hardness of the varnish-surface, which does not permit either of the materials to enter into it.

637. **Note 20.** *Painting and Varnishing on Plaster and Cement.* Ordinary Work. If a bright gloss is objectionable, the coat of varnish is to be eliminated. In the third coat a quantity of a good mixing-varnish sufficient to produce a dull gloss should be mixed into this coat and when applied it should be stippled lightly to prevent laps or brush-marks.

A varnish-sizing gloss-coat should never be applied directly on plaster or on the "basic coater," because it does not penetrate, but dries on the surface. It creates a substantial barricade that does not permit the subsequent paint-coatings to enter into the surface and does not make a substantial foundation. The result of this condition is a sort of "letting-go," and a cracking and scaling of both the varnish-size and the paint, caused by the drying-out, expansion and contraction. For a sizing, a good coat of paint is recommended, containing at least 50 per cent of linseed-oil. There is no objection to 10 or 15 per cent of varnish, applied directly and well-brushed into the plaster-surface. When the "basic coater" is used, the sizing-coat should positively be applied *on top* of the "basic coater."

638. **Note 21.** *Painting and Varnishing on Plaster and Cement.* First-class Work. This formula will produce a paint practically non-absorbent when properly applied, largely because the fine particles of the zinc-oxide close up all voids caused by the coarser pigments. The film is also made stronger and not too hard.

This formula does not produce a perfectly flat finish. By reducing the

oil and varnish in the last coat and increasing the amount of turpentine, any degree of flatness can be obtained. A small quantity of wax thoroughly dissolved in turpentine and added to the final coat will also produce a flat finish. Of course, good judgment must be exercised in the use of these vehicles to obtain the best results. This matter should be left wholly with the painter. The pigments do not enter into the questions of "gloss" or "no gloss." It must be remembered that the flatter a paint-surface is the more liable it is to become absorbent and lose its strength and resisting-power to shield off surface-abrasions.

If a strong gloss is desired, the stippling is to be eliminated and one coat of a good-wearing body-varnish or a full coat of enamel is to be evenly applied.

Very frequently, for fine residences, the walls and ceilings of certain rooms are first covered with light canvas of heavy, unbleached muslin of extra width, or with "prepared muslin" or with "sanitas" especially designed for painting-purposes. In that case it should be specified that the walls and ceilings (the locations to be designated) be properly prepared and sized. All surfaces are to be covered with prepared muslin or canvas of an extra width, and then sized; and all open joints are to be properly glazed with lead-putty. The painting is then to be proceeded with as specified. The "basic coater" should be used, applied directly to the plaster, as it acts as a preventive against discolorations that frequently appear. When a fabric-covering is used it is recommended that it be applied, if possible, to the walls before the wood-finish is put in place, so that around the different openings the wood may cover over a portion of the fabric. Of course, the plaster must be thoroughly dry.

Excellent results have been obtained by covering the ceiling and walls of bath-rooms above the tile wainscoting with three coats of prepared "sanitas," paint and then two coats of white enamel (or it may be tinted), the last coat being rubbed with water and pumice-stone to a china-gloss finish. Care must be taken to have the rubbing uniform and to show no laps. This coating is very sanitary and easily cleaned.

There have lately appeared on the market what is known as "flat-wall coaters." They are paints intended for plaster-surfaces. While many of these have not proven to be worthy of recommendation, there are among them some that are really efficient and excellent in appearance. The question of their permanency is at present a perplexing one; what the results will be after repainting a number of times with the same or with similar materials cannot be predicted with certainty. Many of them are innovations in regard to both pigment and vehicle and must speak for themselves in the future. Some brands look and work well and promise good results. One objection to all of them is, that there is no distinction between the first and the final coat. They are all of the "one mix," and sold as such. The last coat shows a perfectly flat film. The first coat, being the same as the last, is not suited to its purpose, which is to penetrate into the plaster. Its composition, however, will not permit it to do so, and it simply dries on the surface. The result is a breaking-away from the plaster-surface with scaling and flaking. No precautions seem to have been taken to pro-

tect the vehicle and colors from the destructive alkali found in the plaster and cements. It is strongly recommended, therefore, that all plaster and cement-surfaces be first coated with the "basic coater," allowing twenty-four hours to dry; and that for the *first* coat of all prepared flat-wall coaters one-quarter gallon of linseed-oil, with a little dryer, be added. That would cause the paint to penetrate into the plaster, forming a substantial foundation for subsequent coatings, with all danger of discolorations and of the deterioration of the vehicle and colors eliminated.

The stippling of paint should be done very lightly. It should be simply an "evening-up," as it were, for the purpose of getting a uniform, even surface. Coarse stippling should be avoided as it is most unsanitary, and provides a lodgment for microbes, etc., in the surface-abrasions caused by such stippling. It is unsanitary also because, owing to its coarseness, it is cleaned with difficulty. The abandonment of what is known as "sand finish" is also recommended for the above reasons.

In many large office-buildings nearing completion the painter is required to proceed with the painting of plaster and cement-surfaces while they are still damp, and often quite wet. This is ruinous to future good results. A paint used over wet surfaces is at best but temporary and must contain no varnish, very little oil and no zinc-oxide. It must be as soft as possible to permit the dampness to "exhale" through the paint to the surface. The alkali being still active, owing to excess of dampness, staining, blistering and peeling of the paint is a sure result.

639. **Note 22.** *Varnishing and Finishing Hardwoods.* If the location of the finish justifies additional expense and a flat surface is desired, it should be specified that the last coat of varnish be lightly rubbed with oil and pumice-stone to a uniform, dull finish, and that all oil and pumice-stone be afterwards cleaned from the surface. In servants' portions of residences this is not justifiable.

This specification pertains to all open-grained woods such as oak, ash, chestnut, black walnut, etc. If cherry, birch, maple and similar woods are used, the filling with paste-filler is frequently eliminated, the shellac-coating meeting all requirements. It is recommended that the filler be used as specified, but quite thin in body, and carefully wiped from the surface. For birch stained in imitation of mahogany the filler should always be omitted, and the shellac applied directly on the stain, as chemical action frequently takes place when oil is brought in direct contact with mahogany-stain used on birch.

640. **Note 23.** *Varnishing and Finishing Hardwood.* Superior Work. This specification applies to the finishing of red or white mahogany, cherry, birch, walnut, rosewood, etc. In finishing mahogany, or other woods stained with a water-stain in imitation of mahogany, or otherwise, after lightly sandpapering the stain a light coat of shellac is frequently applied directly on the stain, sandpapered lightly and the filler and varnish then proceeded with as specified. White shellac should never be used on dark mahogany or mahogany stained, as it will in time bleach out white, showing a milky film under the varnish. Both the shellac and filler are frequently omitted and a coat of linseed-oil, reduced one-half with turpentine containing a

little dryer, applied directly to the stain. After this has remained on for some time, any oil that is still standing on the surface should be carefuly wiped off and the oil which the wood has absorbed should be allowed to get perfectly dry; the varnishing should then be proceeded with as specified. In this latter case four coats of varnish should be applied.

For white maple or bird's-eye maple, holly, satinwood, etc., the filler and stain should be eliminated and two coats of pure grain-alcohol *white* shellac and three coats of an extra-pale varnish, designed for this class of work, and a rubbing and finishing as directed, should be specified. Oil brought into contact with these and similar woods has a tendency to darken; whereas the purpose is to keep the woods as light and natural in color as possible.

For Italian or French walnut, Circassian walnut and similar woods, where it is so important that the natural colors and shading be preserved, the filler should be eliminated and, applied as above, two coats of pure grain-alcohol white shellac and three coats of a light varnish, should be specified, with the rubbing and finishing as directed.

Fine carved work should never be varnished and rubbed as usually specified. Stain should be specified if necessary to make the carving match the balance of wood in color; one light coat of shellac and two thin coats of wax, rubbed to a hard surface with a stiff-bristle brush should be required. One medium or light coat of a good flat varnish in place of the wax will answer very nicely. The filler with the several coats of varnish will have a tendency to fill up and round the sharp edges and the clean cutting of good carvings.

641. Note 24. *Staining and Waxing Hardwoods.* This specification will apply to oak, ash, chestnut, mahogany, cherry, etc. If a finish with open wood-pores is desired, the filling should be eliminated, but an additional coat of wax should be added.

642. Note 25. *Staining and Waxing Hardwoods.* Superior Finish. This specification applies to oak, ash, chestnut, red and white mahogany, cherry, black walnut, etc., and calls for the very best results. A water-stain is mentioned because it is the best and most satisfactory in showing up to advantage the general beauty of the natural shadings and figures of the woods. In staining it should be emphasized that it does not mean a "covering up," but rather a "bringing out." In oil-stains the coloring-matter is largely composed of pigments of a different character; and as a rule they are permanent, but they have a strong tendency to cover up. Spirit-stains are hard to apply and the results unsatisfactory, the coloring matter very often being "fugitive." Where it is possible to get the color effects by the use of water-stains (and their number is legion), they are recommended above all others. All water-stains raise the grain of the wood more or less, spirit-stains do so very slightly and oil-stains practically not at all. In connection with the use of water-stains, an application of clear water to the oak wood, direct, should be specified, so that the surface-particles may be raised and then cut off with sandpaper, and in order that the water-stain shall have no tendency to further raise the grain. When the water-coating is not used and the water-stain is applied directly, it requires so much sand-papering to again secure a smooth surface that much of the stain and its

effects are removed by the sandpapering. The water-coating is very frequently omitted on less important work. When oil and spirit-stains are used the water-coat should be omitted; for woods other than oak it may also be omitted in the use of the water-stain.

Very frequently, to obtain the desired results, a light coat of shellac is applied directly on top of the stain, after which the filling is proceeded with as specified. The shellac-coating is also frequently eliminated from on top of the filler and the wax applied directly on the filler. The results desired must regulate the procedure.

When an open-grain or pore-effect is desired, the filler should be omitted, but an additional light coat of shellac should be added. It is very essential in this class of work that the shellac be applied thinly and evenly, showing no laps or brush-marks. If a perfectly flat or dead finish is required both filler and shellac-coatings are omitted, and the waxing done as specified directly on the stain; one coat of shellac, however, is recommended. If the natural colors of the woods are to be retained, the staining is omitted and the procedure carried on as specified, observing the above notes.

When white maple and bird's-eye maple, satinwood, holly, French, Italian and Circassian walnut and similar woods, are required to be finished so that they show their natural colors, the water-coat, stain and filler should be eliminated, and the specifications should call for two thin coats of pure grain-alcohol *white shellac* evenly applied directly to the wood without showing laps or brush-marks. Each coat should be sandpapered thoroughly. The waxing should be then proceeded with as specified. When well done this will give the very best results. Mahogany and woods other than those mentioned above are frequently finished in this manner. It is not unusual to eliminate the shellac-coatings, and to wax as specified, directly on the raw wood. When stain is necessary the wax is applied directly on same.

Pleasing results can often be obtained by using a first-class dead or flat varnish. For instance, if a perfectly dead finish is required on open-pore surfaces, the stain is applied, the surface sandpapered, one thin coat of shellac applied, the surface again sandpapered and one coat of a good flat or dead varnish applied, eliminating the waxing. To get a still flatter effect, the shellac, also, is eliminated. This process is not recommended for durability but simply for its effect, and should be used on open-pore woods only, such as oak, where the broken effect of the wood-surface destroys the varnish-coating effect. In this process window-sashes and sills should be protected with a coat of good body-varnish; when dry the gloss can be removed by rubbing.

643. Note 26. *Finishing Pine Floors.* This specification applies to white and yellow pine and also to maple. If this class of flooring is required to be stained, the specifications instead of requiring shellac should require one coat consisting of 25 per cent of linseed-oil and 75 per cent of turpentine, the surface being sandpapered and all imperfections being closed up. One coat of stain, consisting of 40 per cent of linseed-oil and 60 per cent of turpentine, evenly brushed into the wood, and of the required color, is to be applied. This is to be followed with varnish as specified.

The so-called "liquid fillers," that is, prepared fillers, sometimes used to coat over the surface, and permitted to remain there without being rubbed off, should never be used, for the reason that they do not dry thoroughly throughout. Many of them, also, have a tendency to discolor the wood, especially when they begin to bleach out by reason of age, etc.

The reason for going over this work with a very thin coating of oil and turpentine is, that if the stain were applied directly to the wood the result would be a clouded or mottled surface, owing to the natural tendencies of these woods to absorb more in one spot than in another. Very little if any stain should be left on the surface. It should be absorbed uniformly by the wood, and be thoroughly dry before the application of the varnish-coatings.

Where a dull finish is required, the specifications should call for rubbing lightly with oil and pumice-stone to a dull finish. A dull or flat varnish should never be used on floors.

644. Note 27. *Varnish-Finish for Hardwood Floors.* Very frequently color desired for these floors can be obtained by adding necessary coloring matter to the filler. The color of the shellac (white or orange) should be determined by the color required.

If a flat finish is desired, the specifications should call for rubbing with oil and pumice-stone to an even, dull surface. A dull-rubbed surface does not show surface-scratches or abrasions as readily as a bright, varnish-gloss. Under no circumstances should a flat or "dead" varnish be used to obtain this result.

For first-class results the shellac-coating may be eliminated and one additional coat of varnish substituted. It is very essential for the best results that each coat be thoroughly dry before another is applied.

This style of finish is suitable for residences; but proper care must be taken that the surface be not abused, as, at best, a varnished floor-surface is not a very permanent one.

645. Note 28. *Wax-Finish for Hardwood Floors.* This specification applies to practically every class of flooring-woods and produces splendid results as a wax-finish. It is easily cared for by simply going over the surface lightly with turpentine, removing any surface-dirt or imperfections, and afterwards repolishing with one coat of wax as specified. Special care of the floor should be taken in front of the different doorways, as these parts receive the greatest amount of wear.

The whole secret of the success in obtaining a thoroughly practical waxed-floor finish is the recognition of the necessity of using some well-known, efficient floor-wax. Each coat should be thoroughly hardened by the friction caused by good, honest, hard rubbing.

This manner of finishing, as specified, while producing the best-appearing wax-finished floor, has, also, a "slippery" surface, often cited as an objection. To remove, in a large measure, this objection the coat of shellac should be omitted from the specifications.

For dancing or ball-room floors, the two coats of wax should be applied directly to the wood. The wax must be good and the rubbing hard, allowing two days between coats.

Tables and Data Relating to the Strength of Materials.

The following data and tables are given for the benefit of those readers who may not have at hand a special work treating of these subjects. They are based generally upon the formulas and unit stresses given in the author's "Architects' and Builders' Pocket-Book."

1. THE STRENGTH OF WOODEN BEAMS.

Wooden beams are almost invariably square or rectangular-shaped timbers, and that shape only is usually considered in the rules and formulas * for the strength of beams. These should be of such section that the maximum fiber-stress due to transverse bending, the maximum horizontal shear, and the compression across the grain at the end-bearings, do not exceed the allowable unit stresses as set forth in Table XXXVI.

Beams should be braced laterally to prevent buckling when the ratio of length to breadth exceeds twenty, or designed with a reduced fiber-stress from that allowable, where this ratio is exceeded. The percentage of reduction should be as follows:

Ratio of length to width	20 to 30	30 to 40	40 to 50	50 to 60
Percentage of reduction	25	34	42	50

It is also important that beams carry the load without deflecting beyond a limit fixed by the use to which the structure is applied; this limit is generally taken at one-thirtieth of an inch per foot of span for plastered ceilings.

(1) The Value of the Constant, *A*.

The letter *A* in the formulas * for the strength of beams denotes the safe load for a unit beam one inch square and one foot span, loaded at the center. This is also one-eighteenth of the permissible fiber-stress in pounds per square inch. The following are the

*For the formulas used for determining the strength or safe loads for beams see the "Architects' and Builders' Pocket-Book," by F. E. Kidder.

values of A, which are obtained by dividing by eighteen the unit stresses for transverse bending as recommended and those given in the Building Laws of New York, Chicago, Baltimore, Boston, Cincinnati, District of Columbia and the Board of Fire Underwriters.

TABLE XII.

VALUES OF A* IN POUNDS PER SQUARE INCH. COEFFICIENTS RECOMMENDED FOR IRON, STEEL AND WOODEN BEAMS.

Materials.	New York†.	Chicago.	Baltimore.	Boston.	Recommended.
Cast iron..........	167	167	167	167	167
Wrought iron......	667	667	667	667	667
Steel.............	889	889	889	889	889
Yellow pine.......	67	72	100	83	67
White pine........	44	44	56	56	39
Spruce............	44	44	75	56	39
Hemlock..........	33	33	..	..	33
Chestnut..........	44	..	..	..	44
Oak.............	56	67	83	56	67

*These values of A are the nearest whole numbers, discarding fractions.

For safe allowable working unit fiber-stresses for other woods, see Table XXXVI. From these values A may be determined by dividing them by 18. See Table XXXVII for other stresses for woods taken from various building laws.

† Values of A for New York, Cincinnati, District of Columbia and the Board of Fire Underwriters are about identical.

TABLE XIII.

VALUES OF A* IN POUNDS PER SQUARE INCH. COEFFICIENTS RECOMMENDED FOR STONE AND CONCRETE BEAMS.

Materials.	Values of A.	Materials.	Values of A.
Granite	10	Bluestone	17
Limestone	8	Slate	22
Marble	7	Concrete, 1:2:4	1.7
Sandstone	6	Concrete, 1:2:5	1.1

*Values of A for stone beams as recommended are identical with values allowed by the Building Laws of New York and the Board of Fire Underwriters.

For temporary structures the above recommended values of A may be increased 30 per cent.

2. THE RELATIVE STRENGTHS OF BEAMS OF RECTANGULAR CROSS-SECTION.

The relative strength of rectangular beams in different cases is as given in the following table:

TABLE XIV.

RELATIVE STRENGTHS OF BEAMS.

Kinds of supports and manner of loading.	Relative strengths.
Beams supported at both ends:	
Load uniformly distributed	1
Concentrated load at center	1/2
" " " one-third the span	9/16
" " " one-fourth " "	2/3
" " " one-fifth " "	25/32
" " " one-sixth " "	9/10
" " " one-seventh " "	49/48
" " " one-eighth " "	8/7
" " " one-ninth " "	81/64
" " " one-tenth " "	25/18
Beams fixed at one end. Cantilever beams:	
Beams fixed at one end, and loaded with a uniformly distributed load	1/4
Beams fixed at one end, and loaded at the other	1/8
Beams fixed at both ends. Restrained beams:	
Beams fixed at both ends, and loaded at the center	1
Beams fixed at both ends, and loaded with distributed load	1½

These facts are true, also, of beams of any form of uniform cross-section.

When a beam of square cross-section is supported on its edge, instead of on its side, that is, when its diagonal is vertical, it will bear about seven-tenths as great a breaking-load as it will bear when it is placed in the latter position.

To find from the tables the safe center-load of a given beam, first find the safe distributed load as in Example 2, page 816, and divide it by 2. To find the safe load when concentrated at some other point than the center, first find the safe distributed load for the given span, and divide by the factor of relative strength given in Table XIV. To find the size of beam to support a given concentrated load, multiply the given load by the factor of relative strength corresponding with the position of the load as given in Table XIV, and then proceed as in Example 3, page 816.

3. NOMINAL AND STANDARD SIZES OF BEAMS.

The tables may be used for beams that measure less than the nominal dimensions. Dressed beams, and in many localities floor-joists carried in stock, are more or less "scant" of the nominal dimensions, and for such joists a reduction in the safe load must be made to correspond to the reduction in size. The dressed sizes are generally ¼ of an inch scant up to 4 inches in breadth, above which they are ½ an inch scant; while in depth they are all generally ½ an inch less than the nominal sizes. The safe loads may be obtained by multiplying the safe load as given in the Tables XVI to XXIV by the factors given in the following table:

TABLE XV.

CONVERSION-FACTORS FOR BEAMS OF COMMERCIAL OR STANDARD SIZES.

Cross-section of beams in inches.	Factors.	Cross-section of beams in inches.	Factors.
1¾×5½	1.47	1¾×11½	1.61
2¾×5½	2.31	2¾×11½	2.53
1¾×6½	1.51	1¾×13½	1.63
2¾×6½	2.51	2¾×13½	2.56
1¾×7½	1.54	1¾×15½	1.65
2¾×7½	2.42	2¾×15½	2.58
1¾×9½	1.58	1¾×17½	1.65
2¾×9½	2.48	2¾×17½	2.60

(1) Example of the Use of Table XV.

Example 1. What is the safe load for a 2¾ by 13½-inch spruce beam, 18-foot span?

Solution. From Table XVII we find the safe load for a 1 by 14-inch beam to be 847 pounds. Multiplying this by 2.56 we have 2,178 pounds as the safe distributed load for a beam 2¾ by 13½ inches in cross-section. For a full, "nominal" size, 3 by 14-inch, the safe load would be 2,541 pounds.

4. STONE AND CONCRETE BEAMS.

(1) Stone Beams. The same formulas apply to stone and wooden beams of rectangular cross-section, the coefficients recommended in Table XIII being used. Sandstone beams should never be subjected to any heavy loads, and when used as lintels they should be supported by steel beams or relieved by brick arches over or back of them.

(2) Concrete Beams. These are generally reinforced by steel rods, but when used without reinforcement, the coefficient A given in the table is recommended.

5. EXPLANATION OF TABLES XVI TO XXIV FOR THE STRENGTH AND STIFFNESS OF WOODEN BEAMS.

Tables for the strength and stiffness of wooden beams 1 inch in breadth are given on the following pages. To find the strength, or safe load, for any other breadth, multiply the proper tabular value in pounds by the breadth of the beam in inches.

To obtain the required breadth for any given load, divide the load in pounds by the proper tabular value.

In the heading of the tables, the maximum fiber-stress S is given, and the corresponding values of A, so that designers who prefer to use for any wood a value different from that recommended, need only to look up the table based on the value they wish to use. For certain cases and in some cities, for example, the building laws specify 1300, 1500 and 1800 pounds per square inch as the values of S to be used for yellow pine. Tables XXII, XXIII, and XXIV, based upon these values, have therefore been added.

Since the resistance of timber to shearing is small when compared to its resistance to tension and compression, the safe load a wooden beam of short span can carry is governed, not by its resistance to cross-breaking, but by its resistance to shear along its neutral axis. Wooden beams and joists, therefore, should be dimensioned to safely withstand this shearing action.

The ratio of the shearing-strength to that of transverse rupture is not exactly the same for different kinds of wood; but for practical use and in the tables it has been assumed to be 1/12 of the working fiber-stress. As it can be shown * that the ratio to the span to the depth of a rectangular beam, uniformly loaded, is directly proportional to its cross-breaking stress and shearing working-stress, the loads in the tables are figured for the permissible fiber-stress, when the length of span is twelve or more times the depth of the beam; while for shorter lengths the loads are governed by the shear.

To determine the safe load on beams that will not cause a deflection exceeding one three-hundred-and-sixtieth of the span, values have been placed directly under the values for the safe loads for strength. These values are based on the modulus of elasticity, E, given for each table.

The formula for flexure used in determining the safe, uniformly distributed loads in the tables is

$$M=\frac{SI}{c}=\frac{Sbd^2}{6}=\frac{Wl}{8} \qquad \text{Hence, } W=\frac{4bd^2 S}{3l}, \text{ in which}$$

l is the span in inches. The formula for shear is

$$W=\frac{4bd\,S_s}{3}$$

and the formula for deflection is

$$W=\frac{Ed^3}{8100l^2}, \text{ in which } l \text{ is the span in feet.}$$

In these formulas

W = the total load in pounds, uniformly distributed;

b = the breadth in inches;

d = the depth in inches;

l = the span (in inches in the flexure-formula and in feet in the deflection-formula);

S = the maximum fiber-stress in pounds per square inch;

S_s = the horizontal shearing-stress along the neutral axis, and $=\frac{S}{12}$;

E = modulus of elasticity.

*See page 55, "Materials of Construction," by J. B. Johnson.

(1) Examples of the Use of Tables for the Strength and Stiffness of Wooden Beams.

Example 2. What is the uniformly distributed load, corresponding to a fiber-stress of 1,200 pounds per square inch, for an 8 by 14-inch southern long-leaf pine beam, supported at both ends and having a clear space of 24 feet?

Solution. In Table XXI the safe load for this depth and span for a 1-inch thickness or width is 1,090 pounds. Therefore, 1,090 pounds × 8 = 8,720 pounds, the total safe load for the beam. If the deflection of this beam is not to exceed 1/360 of the span, the safe load for a 1-inch thickness should not exceed 882 pounds. Then 882 pounds × 8 = 7,056 pounds, will be the maximum load to be used in this case.

Example 3. What should be the size of a Douglas fir beam, with a clear span of 18 feet, to safely carry a distributed load of 6,400 pounds?

Solution. From Table XIX, for Douglas fir beams, we find that a beam 12 inches deep and 1 inch thick, with an 18-foot span, will safely support 711 pounds; and dividing the load, 6,400 pounds, by 711, we have 9.0 for the breadth of the beam in inches. Hence the beam should be 9 by 12 inches in cross-section, to carry a distributed load of 6,400 pounds when the span is 18 feet. As the deflection-load of 593 pounds may be increased 60 per cent for Douglas fir, the beam will be safe for deflection; if, however, the beam is to be of cypress, 593 must be used in place of 711, in order to determine its breadth, which in that case would be 11 inches. Hence the cypress beam should be 11 by 12 inches in cross-section.

6. TABLES* OF THE STRENGTH AND STIFFNESS OF WOODEN BEAMS.

The following tables, from XVI to XXIV, give the safe load in pounds, uniformly distributed, for rectangular wooden beams, one inch wide and supported at each end. A general explanation is given in the preceding subdivision, 5, of the Appendix. The maximum fiber-stress, S, varies from 600 pounds per square inch in Table XVI, to 1800 in Table XXIV. These values and the values for A (see subdivision 1) and E, the modulus of elasticity, and also the different woods for which the loads are recommended, are given at the head of each table.

Loads above the heavy, zigzag black lines are calculated for resistance to shear. Where two loads are given, the upper load is calculated for strength and the lower load for a deflection not exceeding 1/360 of the span.

The loads given in Tables XVI to XXIV for the fiber-stresses are correct; but for convenience in using the tables, each figure in the units column may be made a cypher, and each figure in the tens column may be increased by one when the unit figure is six or greater. Thus, 505 would be 500, 506 would be 510, etc.

*The Editor is indebted to Mr. F. H. Kindl, Associate Editor for Chapters XVI and XVII of Kidder's "Architects' and Builders' Pocket-Book," for the complete refiguring of Tables XVI to XXIV.

TABLE XVI.

Safe Distributed Loads in Pounds for Wooden Beams.

Hemlock. $S=600$ lbs. per sq. in. $A=33$. $E=900{,}000$ lbs. per sq. in.

Span of beam in feet.	The first horizontal line gives the depth of beam in inches. Loads are for beams one inch wide.						
	6	8	10	12	14	16	18
6	400	533	666	800	933	1,066	1,200
7	343	533	666	800	933	1,066	1,200
8	300	533	666	800	933	1,066	1,200
9	266	474	666	800	933	1,066	1,200
10	240 240	427	666	800	933	1,066	1,200
11	218 199	388	605	800	933	1,066	1,200
12	200 166	356	555	800	933	1,066	1,200
13	185 143	328	513	738	933	1,066	1,200
14	171 122	305 291	477	686	933	1,066	1,200
15	160 107	285 253	445	640	871	1,066	1,200
16	150 94	267 222	417	600	817	1,066	1,200
17	....	251 197	392 384	565	762	1,003	1,200
18	....	237 175	371 343	534	726	948	1,200
19	....	225 157	351 308	505	688	898	1,137
20	....	213 142	333 277	480 480	653	854	1,080
21	....	....	317 252	462 435	623	818	1,029
22	....	....	303 229	436 397	594	776	982
23	....	....	290 211	417 363	568	742	939
24	....	....	278 193	400 334	545 529	712	900
25	....	....	....	384 308	523 488	683	864
26	....	....	....	369 284	503 452	657	831
27	....	....	....	356 264	482 418	633 625	800
28	....	....	....	343 245	467 389	609 582	772
29	....	....	....	....	451 353	589 542	745
30	....	....	....	....	436 339	569 505	720 720

TABLE XVII.

SAFE DISTRIBUTED LOADS IN POUNDS FOR WOODEN BEAMS.

White Pine, Spruce and Eastern Fir. $S = 700$ lbs. per sq. in. $A = 39$.
$E = 1,000,000$ lbs. per sq. in.

Span of beam in feet.	The first horizontal line gives the depth of beam in inches. Loads are for beams one inch wide.						
	6	8	10	12	14	16	18
6	467	622	777	933	1,089	1,244	1,400
7	400	622	777	933	1,089	1,244	1,400
8	350	622	777	933	1,089	1,244	1,400
9	311	552	777	933	1,089	1,244	1,400
10	280 267	497	777	933	1,089	1,244	1,400
11	255 221	453	707	933	1,089	1,244	1,400
12	233 185	415	648	933	1,089	1,244	1,400
13	216 158	383 374	598	861	1,089	1,244	1,400
14	200 136	356 323	556	800	1,089	1,244	1,400
15	187 119	332 281	518	747	1,016	1,244	1,400
16	175 104	311 247	486 482	700	952	1,244	1,400
17	....	293 219	458 427	660	897	1,172	1,400
18	....	276 195	433 381	623	847	1,107	1,400
19	....	262 175	410 342	590	802	1,048	1,326
20	....	....	389 308	560 534	762	996	1,260
21	....	....	370 280	534 484	726	948	1,200
22	....	....	354 255	509 441	692	906	1,144
23	....	....	333 234	487 403	662 641	866	1,096
24	....	....	321 215	468 371	635 588	830	1,050
25	....	....	....	443 312	610 512	796	1,008
26	....	....	....	430 316	586 502	766 750	970
27	....	....	....	415 293	565 465	738 695	934
28	....	....	....	400 272	544 432	711 646	900
29	....	....	....	....	526 403	687 602	868 856
30	....	....	....	....	508 377	664 562	840 800

TABLE XVIII.

Safe Distributed Loads in Pounds for Wooden Beams.

California Redwood and Cedar. $S=750$ lbs. per sq. in. $A=41.7$
$E=700,000$ lbs. per sq. in.

Span of beam in feet.	The first horizontal line gives the depth of beam in inches. Loads are for beams one inch wide.						
	6	8	10	12	14	16	18
6	500	667	833	1,000	1,167	1,333	1,500
7	428 382	667	833	1,000	1,167	1,333	1,500
8	375 292	667	833	1,000	1,167	1,333	1,500
9	333 231	592 547	833	1,000	1,167	1,333	1,500
10	300 187	533 443	833	1,000	1,167	1,333	1,500
11	274 155	485 366	757 714	1,000	1,167	1,333	1,500
12	250 130	445 307	641 600	1,000	1,167	1,333	1,500
13	231 110	410 262	641 512	923 885	1,167	1,333	1,500
14	214 95	382 226	595 441	857 763	1,167	1,333	1,500
15	....	356 197	556 384	800 665	1,088 1,060	1,333	1,500
16	....	333 173	521 337	750 584	1,020 929	1,333	1,500
17	....	....	491 299	706 518	961 822	1,254 1,223	1.500
18	....	....	463 267	667 462	908 733	1,184 1,090	1,500
19	....	....	439 240	632 414	860 658	1,122 982	1,421 1,396
20	....	....	....	600 374	816 594	1,066 886	1,350 1,258
21	....	....	....	572 339	778 526	1,016 803	1,286 1,144
22	....	....	....	547 309	742 491	970 732	1,227 1,042
23	....	....	....	522 282	710 448	928 670	1,174 954
24	....	....	....	500 260	681 412	890 616	1,125 876
25	....	....	....	480 239	653 380	854 567	1,080 808
26	....	....	....	463 221	628 351	821 525	1,038 747
27	....	....	....	444 205	605 326	791 487	1,000 692
28	....	....	....	428 190	583 203	762 452	965 644
29	....	....	....	....	563 282	736 421	931 600
30	....	....	....	....	544 264	712 393	900 560

TABLE XIX.

Safe Distributed Loads in Pounds for Wooden Beams.

Douglas Fir, Norway Pine, Cypress and Chestnut. $S = 800$ lbs. per sq. in. $A = 44$. $E = 900{,}000$ lbs. per sq. in. For safe deflecting loads for Douglas Fir, add 60 per cent. and for Norway Pine, 20 per cent. to the values given.

Span of beam in feet.	The first horizontal line gives the depth of beam in inches. Loads are for beams one inch wide.						
	6	8	10	12	14	16	18
6	533	711	889	1,066	1,244	1,422	[illegible]
7	457	711	889	1,066	1,244	1,422	1,600
8	400 375	711	889	1,066	1,244	1,422	1,600
9	356 296	632	889	1,066	1,244	1,422	1,600
10	320 240	569 569	889	1,066	1,244	1,422	1,600
11	291 199	517 470	809	1,066	1,244	1,422	1,600
12	267 166	474 395	742	1,066	1,244	1,422	1,600
13	246 142	438 337	684 658	985	1,244	1,422	1,600
14	229 122	407 291	635 567	914	1,244	1,422	1,600
15	214 107	379 253	593 494	854 854	1,161	1,422	1,600
16	200 94	356 222	556 432	800 750	1,089	1,422	1,600
17	. . .	335 197	524 384	754 665	1,026	1,339	1,600
18	. . . .	316 175	494 343	711 [illegible]	968 914	1,264	1,600
19	. .	300 157	[illegible] 308	674 532	917 846	1,198	1,517
20	. .	284 142	445 277	640 [illegible]	871 752	1,138 1,138	1,441
21	. . .	. .	423 252	609 435	830 692	1,084 1,032	1,372
22	. . .	.	404 229	[illegible] 397	792 630	1,036 941	1,309
23	. .		387 211	557 363	758 577	990 860	1,253 1,225
24	. . .	. . .	371 193	534 334	726 529	949 790	1,200 1,126
25	. . . .		.	512 308	697 488	911 728	1,152 1,037
26	. .	.	.	492 284	670 452	876 675	1,108 960
27	. .	. . . .	. . .	474 264	646 418	843 625	1,068 890
28	. . .	. .	. .	457 245	622 389	813 582	1,029 827
29	.			. .	601 353	785 542	993 770
30	. . . .	. .		. .	581 339	759 506	960 720

TABLE XX.

Safe Distributed Loads in Pounds for Wooden Beams.

Short-Leaf Yellow Pine. $S = 1,000$ lbs. per sq. in. $A = 55.6$. $E = 1,200,000$ lbs. per sq. in.

Span of beam in feet.	The first horizontal line gives the depth of beam in inches. Loads are for beams one inch wide.						
	6	8	10	12	14	16	18
6	667	889	1,111	1,333	1,556	1,778	2,000
7	571	889	1,111	1,333	1,556	1,778	2,000
8	500 500	889	1,111	1,333	1,556	1,778	2,000
9	444 395	790	1,111	1,333	1,556	1,778	2,000
10	400 320	711	1,111	1,333	1,556	1,778	2,000
11	364 265	647 628	1,010	1,333	1,556	1,778	2,000
12	333 222	593 527	926	1,333	1,556	1,778	2,000
13	308 190	547 449	855	1,231	1,556	1,778	2,000
14	286 163	508 388	794 757	1,143	1,556	1,778	2,000
15	267 143	474 337	741 659	1,067	1,452	1,778	2,000
16	250 125	445 296	695 578	1,000 1,000	1,361	1,778	2,000
17	....	419 263	654 512	942 886	1,281	1,674	2,000
18	....	395 234	618 457	890 790	1,210	1,581	2,000
19	....	374 210	585 410	843 710	1,146 1,126	1,498	1,895
20	....	356 190	556 370	800 641	1,088 1,016	1,423	1,800
21	....	....	528 336	762 581	1,307 922	1,355	1,714
22	....	....	505 306	727 529	990 841	1,293 1,254	1,636
23	....	....	483 281	696 484	947 770	1,237 1,147	1,565
24	....	....	463 258	667 445	908 706	1,186 1,053	1,500 1,500
25	....	....	....	640 410	871 650	1,138 972	1,440 1,384
26	....	....	....	615 380	838 602	1,094 900	1,385 1,280
27	....	....	....	593 352	807 558	1,054 834	1,334 1,186
28	....	....	....	572 327	778 518	1,016 776	1,286 1,103
29	....	....	....	....	751 484	982 725	1,241 1,027
30	....	....	....	....	726 452	949 674	1,200 960

TABLE XXI.

Safe Distributed Loads in Pounds For Wooden Beams.

White Oak and Southern Long-Leaf Pine.* $S=1{,}200$ lbs. per sq. in. $A=66.7$. $E=1{,}500{,}000$ lbs. per sq. in.

Span of beam in feet.	The first horizontal line gives the depth of beam in inches. Loads are for beams one inch wide.						
	6	8	10	12	14	16	18
6	800	1,067	1,333	1,600	1,867	2,133	2,400
7	686	1,067	1,333	1,600	1,867	2,133	2,400
8	600	1,067	1,333	1,600	1,867	2,133	2,400
9	533 495	949	1,333	1,600	1,867	2,133	2,400
10	480 400	854	1,333	1,600	1,867	2,133	2,400
11	437 332	776	1,212	1,600	1,867	2,133	2,400
12	400 278	711 658	1,111	1,600	1,867	2,133	2,400
13	369 247	656 561	1,026	1,477	1,867	2,133	2,400
14	343 204	610 485	953 946	1,371	1,867	2,133	2,400
15	320 179	569 422	890 824	1,280	1,741	2,133	2,400
16	300 156	533 371	834 724	1,200	1,633	2,133	2,400
17	....	502 329	785 642	1,130 1,108	1,537	2,009	2,400
18	....	474 293	741 572	1,067 990	1,452	1,898	2,400
19	....	449 263	702 513	1,010 886	1,375	1,795	2,274
20	....	426 237	666 462	960 802	1,306 1,272	1,708	2,160
21	....	....	634 420	914 726	1,245 1,154	1,626	2,057
22	....	....	606 383	872 662	1,188 1,051	1,552	1,968
23	....	....	579 351	835 605	1,136 962	1,484 1,435	1,878
24	....	....	556 322	800 557	1,090 882	1,423 1,318	1,800
25	....	....	....	768 513	1,045 813	1,366 1,215	1,728 1,727
26	....	....	....	738 473	1,006 753	1,313 1,125	1,662 1,596
27	....	....	....	711 440	969 698	1,265 1,043	1,600 1,480
28	....	....	....	686 410	933 648	1,218 970	1,543 1,377
29	....	....	....	....	902 605	1,178 903	1,489 1,284
30	....	....	....	....	871 566	1,138 843	1,440 1,200

*For tables of safe loads corresponding to fiber-stresses of 1,300, 1,500 and 1,800 pounds per square inch, see Tables XXII, XXIII and XXIV, respectively.

TABLE XXII.

Safe Distributed Loads in Pounds for Wooden Beams.

$S = 1{,}300$ lbs. per sq. in. $A = 72.2$.

Span of beam in feet.	The first horizontal line gives the depth of beam in inches. Loads are for beams one inch wide.						
	6	8	10	12	14	16	18
6	867	1,155	1,444	1,733	2,022	2,311	2,600
7	743	1,155	1,444	1,733	2,022	2,311	2,600
8	650	1 155	1,444	1,733	2,022	2,311	2,600
9	567	1,027	1,444	1,733	2,022	2,311	2,600
10	520	924	1,444	1,733	2,022	2,311	2,600
11	473	840	1,311	1,733	2,022	2,311	2,600
12	433	770	1,200	1,733	2,022	2,311	2,600
13	400	711	1,111	1,600	2,022	2,311	2,600
14	371	660	1,032	1,486	2,022	2,311	2,600
15	347	616	963	1,387	1,887	2,311	2,600
16	325	578	903	1,300	1,770	2,311	2,600
17	....	544	849	1,224	1,664	2,175	2,600
18	....	514	802	1,156	1,572	2,054	2,600
19	....	487	760	1,095	1,490	1,946	2,463
20	....	462	722	1,040	1,415	1,849	2,340
21	....	....	638	990	1,348	1,761	2,229
22	....	....	657	945	1,286	1,681	2,127
23	....	....	628	904	1,230	1,608	2,035
24	....	....	602	867	1,179	1,511	1,950
25	....	....	....	832	1,132	1,479	1,872
26	....	....	....	800	1,088	1,422	1,800
27	....	....	....	770	1,048	1,369	1,733
28	....	....	....	743	1,011	1,321	1,671
29	....	....	....	....	976	1,275	1,614
30	....	....	....	....	943	1,232	1,560

TABLE XXIII.

Safe Distributed Loads in Pounds for Wooden Beams.

$S = 1,500$ lbs. per sq. in. $A = 83.3$.

Span of beam in feet.	The first horizontal line gives the depth of beam in inches. Loads are for beams one inch wide.						
	6	8	10	12	14	16	18
6	1,000	1,333	1,667	2,000	2,333	2,667	3,000
7	857	1,333	1,667	2,000	2,333	2,667	3,000
8	750	1,333	1,667	2,000	2,333	2,667	3,000
9	667	1,185	1,667	2,000	2,333	2,667	3,000
10	600	1,067	1,667	2,000	2,333	2,667	3,000
11	548	970	1,515	2,000	2,333	2,667	3,000
12	500	890	1,390	2,000	2,333	2,667	3,000
13	462	820	1,282	1,846	2,333	2,667	3,000
14	428	764	1,190	1,714	2,333	2,667	3,000
15	....	712	1,112	1,600	2,178	2,667	3,000
16	....	667	1,042	1,500	2,042	2,667	3,000
17	....	....	982	1,412	1,974	2,510	3,000
18	....	....	926	1,334	1,815	2,370	3,000
19	....	....	878	1,264	1,720	2,246	2,842
20	....	....	....	1,200	1,632	2,133	2,700
21	....	....	....	1,144	1,556	2,032	2,571
22	....	....	....	1,094	1,484	1,940	2,455
23	....	....	....	1,044	1,420	1,856	2,348
24	....	....	....	1,000	1,362	1,780	2,250
25	....	....	....	960	1,306	1,708	2,160
26	....	....	....	926	1,256	1,642	2,076
27	....	....	....	888	1,210	1,582	2,000
28	....	....	....	856	1,166	1,524	1,930
29	....	....	....	....	1,126	1,472	1,862
30	....	....	....	....	1,088	1,422	1,800

TABLE XXIV.

Safe Distributed Loads in Pounds For Wooden Beams.

$S = 1{,}800$ lbs. per sq. in. $A = 100$.

Span of beam in feet.	The first horizontal line gives the depth of beam in inches. Loads are for beams one inch wide.						
	6	8	10	12	14	16	18
6	1,200	1,600	2,000	2,400	2,800	3,200	3,600
7	1,030	1,600	2,000	2,400	2,800	3,200	3,600
8	900	1,600	2,000	2,400	2,800	3,200	3,600
9	800	1,422	2,000	2,400	2,800	3,200	3,600
10	720	1,280	2,000	2,400	2,800	3,200	3,600
11	655	1,164	1,818	2,400	2,800	3,200	3,600
12	600	1,067	1,667	2,400	2,800	3,200	3,600
13	554	985	1,539	2,215	2,800	3,200	3,600
14	514	914	1,428	2,057	2,800	3,200	3,600
15	480	853	1,333	1,920	2,613	3,200	3,600
16	450	800	1,250	1,800	2,450	3,200	3,600
17	....	753	1,176	1,694	2,306	3,012	3,600
18	....	711	1,111	1,600	2,178	2,844	3,600
19	....	674	1,053	1,516	2,063	2,695	3,411
20	....	640	1,000	1,440	1,960	2,560	3,240
21	....	....	....	1,371	1,867	2,438	3,086
22	....	....	....	1,309	1,782	2,327	2,945
23	....	....	....	1,252	1,704	2,226	2,817
24	....	....	....	1,200	1,633	2,133	2,700
25	....	....	....	1,152	1,568	2,048	2,592
26	....	....	....	1,108	1,508	1,969	2,492
27	....	....	....	1,067	1,452	1,896	2,400
28	....	....	....	1,029	1,400	1,829	2,314
29	....	....	....	....	1,352	1,766	2,235
30	....	....	....	....	1,307	1,707	2,160

7. THE MAXIMUM SPANS FOR FLOOR JOISTS, CEILING-JOISTS AND RAFTERS.*

When the span of a wooden joist exceeds about twelve times its depth the joist will usually deflect so much under its full, safe load that it will crack plastering applied on the under side; and as floor and ceiling-joists are generally used for spans greater than twelve times their depth, they should be computed by the formulas for stiffness rather than by those for strength.

In determining the size of floor-joists the superimposed load and the span are the two elements which vary the most, the joists themselves being usually sawed to regular sizes while the spacing on centers is generally either 12 or 16 inches. In tabulating the sizes of joists for different loads, tables giving the maximum safe spans are the most convenient for general use, and with this view the following tables have been prepared, showing at a glance the maximum spans for which different sizes of floor and ceiling-joists should be used for different loads and spacings. It is believed that they will be found applicable to most buildings in which wooden floor-joists are used.

Knowing the size of the room to be floored or roofed and the purpose for which it is to be used, the size of the required joists can be determined at a glance. Incidentally the tables show also which kind of wood will be most economical.

If the joists must be of different lengths, owing to the irregular shape of the room, the spacing or thickness of the joists may be varied, so that the same depth may be used throughout.

The only precautions necessary in the use of these tables are in regard to the superimposed loads and the actual sizes of the timbers.

The total loads per square foot for which the maximum spans have been computed are given at the head of each table. The actual weight of the floor, including the joists, flooring, plastering, deafening, etc., subtracted from the total load will give the superimposed load, that is, the load which the floor is expected to carry.

The superimposed load to be assumed for any given building is to a large extent a matter of judgment, as circumstances may demand a higher limit for one building than for another, even of the same general class. In general the tables may be considered safe for the classes of buildings indicated in each case.

*The editor is indebted to Mr. A. T. North, M. Am. Soc. C. E., for valuable suggestions and assistance in revising this and other parts of the work.

In some localities, framing-lumber is often sawed a little scant in both thickness and depth, and wherever this is done a corresponding reduction must be made in the safe span. A reduction should also be made for any cutting of the joists that may be required.

No allowance has been made for partitions, and when they are to be supported by the floor-joists, additional joists should be used or the span reduced according to the relative direction or position of the partitions and joists.

Tables XXV to XXIX, inclusive, were computed by the formula for stiffness, on the assumption that the deflection should not exceed 1/30 of an inch per foot of span. Tables XXX and XXXI were computed by the formula for strength.

Tables XXV to XXXI, inclusive, are based upon practice recommended by the editor, and architects and builders are expected to modify them, if necessary, to meet any special or unusual requirements of building laws.

See page 839, table XXXVI.

*Compiled and adapted largely from recommended unit stresses adopted by the Association of Railway Superintendents of Bridges and Buildings, and by the American Railway Engineering Association. The unit stresses are for unseasoned timber, and may be increased 30 per cent. for protected timber not subjected to impact, as in buildings.

†The average ultimate breaking unit stresses may be obtained by multiplying the working unit stresses by the factors of safety at the top of columns.

‡These and some other values are considerably higher than those of the building laws of many cities, larger factors of safety being used in many of the building laws.

8. TABLES FOR MAXIMUM SPANS FOR JOISTS AND RAFTERS.

TABLE XXV.

MAXIMUM SPAN FOR CEILING-JOISTS.

Total load, 20 pounds per square foot.

Sizes of joists.	Dist. on centers.	Hemlock. *E=900,000.		Spruce, white pine. E=1,000,000.		Norway pine. E=1,100,000.		Southern short-leaf yellow pine. E=1,200,000.		Southern long-leaf yellow pine, Douglas fir. E=1,500,000.	
ins.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.
2×4	12	8	11	9	3	9	6	9	10	10	7
2×4	16	8	1	8	5	8	8	8	11	9	7
2×6	12	13	5	13	10	14	4	14	9	15	10
2×6	16	12	2	12	7	13	0	13	5	14	5
2×8	12	17	10	18	6	19	1	19	8	21	2
2×8	16	16	3	16	10	17	4	17	10	19	3
2×8	20	15	1	15	7	16	1	16	7	17	10
Total load, 24 pounds per square foot.											
2×10	12	21	0	21	9	22	5	23	1	24	11
2×10	16	19	1	19	8	20	5	21	0	22	2
2×10	20	17	8	18	4	18	11	19	6	21	0
2×12	12	25	2	26	0	26	11	27	9	29	11
2×12	16	22	11	23	9	24	6	25	2	27	2
2×12	20	21	3	22	0	22	9	23	5	25	2

*E is the modulus of elasticity and is in pounds per square inch.

TABLE XXVI.

Maximum Span for Floor-Joists for Dwellings, Tenements and Grammar-School Rooms with Fixed Desks.

Total load, 60 pounds per square foot.

Sizes of joists. ins.	Dist. on centers. ins.	Hemlock. *E=900,000. ft.	ins.	Spruce white pine. E=1,000,000. ft.	ins.	Norway pine. E=1,100,000. ft.	ins.	Southern short-leaf yellow pine. E=1,200,000. ft.	ins.	Southern long-leaf yellow pine, Douglas fir. E=1,500,000. ft.	ins.
2×6	12	9	3	9	7	9	11	10	3	11	0
2×6	16	8	5	8	9	9	0	9	3	10	0
3×6	12	10	8	11	0	11	4	11	8	12	7
3×6	16	9	8	10	0	10	4	10	8	11	5
2×8	12	12	4	12	10	12	3	13	8	14	8
2×8	16	11	3	11	8	12	0	12	4	13	4
3×8	12	14	2	14	8	15	2	15	7	16	10
3×8	16	12	11	13	4	13	9	14	2	15	3
2×10	12	15	6	16	0	16	7	17	0	18	3
2×10	16	14	1	14	7	15	0	15	6	16	8
Total load, 66 pounds per square foot.											
3×10	12	17	2	17	0	13	4	18	11	20	4
3×10	16	15	7	16	2	16	8	17	2	18	6
2×12	12	18	0	18	8	19	3	19	8	21	4
2×12	16	16	4	16	11	17	8	18	0	19	5
3×12	12	20	7	21	4	22	0	22	8	24	5
3×12	16	18	8	19	4	20	0	20	7	22	2
2×14	12	21	0	21	11	22	5	23	1	24	10
2×14	16	19	1	19	9	20	5	21	0	22	7
2½×14	12	22	7	23	5	24	2	24	11	26	10
2½×14	16	20	6	21	3	21	11	22	7	24	4
3×14	12	24	0	24	10	25	8	26	5	28	6
3×14	16	21	10	22	7	23	4	24	0	25	10

*E is the modulus of elasticity and is in pounds per square inch.

TABLE XXVII.

Maximum Span for Floor-Joists for Office-Buildings.

Total load, 93 pounds per square foot.

Sizes of joists.	Dist. on centers.	Hemlock. *E=900,000.		Spruce, white pine. E=1,000,000.		Norway pine. E=1,100,000.		Southern short-leaf yellow pine. E=1,200,000.		Southern long-leaf yellow pine, Douglas fir. E=1,500,000.	
ins.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.
3×8	12	12	3	12	8	13	1	13	6	14	6
3×8	16	11	1	11	6	11	11	12	3	13	2
2×10	12	13	4	13	10	14	3	14	8	15	10
2×10	16	12	2	12	7	13	0	13	4	14	5
3×10	12	15	4	15	10	16	4	16	10	18	2
3×10	16	13	11	14	5	14	10	15	4	16	7
2×12	12	16	0	16	7	17	2	17	8	19	0
2×12	16	14	7	15	1	15	7	16	0	17	3
Total load, 96 pounds per square foot.											
3×12	12	18	2	18	10	19	5	20	0	21	6
3×12	16	16	6	17	1	17	8	18	2	19	7
2×14	12	18	6	19	2	19	10	20	5	21	11
2×14	16	16	10	17	5	13	0	18	6	19	11
2½×14	12	19	11	20	8	21	4	22	0	23	8
2½×14	16	18	2	18	9	19	5	19	11	21	6
3×14	12	21	2	21	11	22	8	23	4	23	2
3×14	16	19	3	19	11	20	7	21	2	22	10

*E is the modulus of elasticity and is in pounds per square inch.

TABLE XXVIII.

Maximum Span for Floor-Joists for Churches and Theatres with Fixed Seats.

Total load, 102 pounds per square foot.

Sizes of joists.	Dist. on centers.	Hemlock. *E=900,000.		Spruce white pine. E=1,000,000.		Norway pine. E=1,100,000.		Southern short-leaf yellow pine. E=1,200,000.		Southern long-leaf yellow pine, Douglas fir. E=1,500,000.	
ins.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.
3×8	12	11	10	12	3	12	8	13	1	14	1
3×8	16	10	9	11	2	11	6	11	11	12	9
2×10	12	12	11	13	5	13	10	14	3	15	4
2×10	16	11	9	12	2	12	7	13	0	13	11
3×10	12	14	10	15	4	15	10	16	4	17	7
3×10	16	13	6	13	11	14	5	14	10	16	0
2×12	12	15	7	16	1	16	8	17	1	18	5
2×12	16	14	2	14	8	15	1	15	7	16	9
Total load, 105 pounds per square foot.											
3×12	12	17	8	18	3	18	10	19	5	20	11
3×12	16	16	0	16	7	17	1	17	8	19	0
2×14	12	18	0	18	7	19	3	19	8	21	4
2×14	16	16	4	16	11	17	5	18	0	19	4
2½×14	12	19	4	20	1	20	8	21	4	23	0
2½×14	16	17	7	18	3	18	10	19	4	20	11
3×14	12	20	7	21	4	22	0	22	8	24	5
3×14	13	18	8	19	4	20	0	20	7	22	2

*E is the modulus of elasticity and is in pounds per square inch.

TABLE XXIX.

Maximum Span for Floor-Joists for Assembly-Halls and Corridors.

Total load, 123 pounds per square foot.

Sizes of joists.	Dist. on centers.	Hemlock. *E = 900,000.		Spruce, white pine. E = 1,000,000.		Norway pine. E = 1,100,000.		Southern short-leaf yellow pine. E = 1,200,000.		Southern long-leaf yellow pine, Douglas fir. E = 1,500,000.	
ins.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.
3×8	12	11	2	11	7	11	11	12	3	13	3
3×8	16	11	0	10	6	10	10	11	2	12	0
2×10	12	12	2	12	7	13	0	13	5	14	5
2×10	16	11	1	11	5	11	10	12	2	13	1
3×10	12	13	11	14	5	14	11	15	4	16	6
3×10	16	12	8	13	1	13	7	13	11	15	0
2×12	12	14	7	15	2	15	8	16	1	17	4
2×12	16	13	3	13	9	14	2	14	8	15	9
Total load, 126 pounds per square foot.											
3×12	12	16	7	17	2	17	9	18	3	19	8
3×12	16	15	1	15	7	16	1	16	7	17	10
2×14	12	16	11	17	6	18	1	18	7	20	1
2×14	16	15	4	15	11	16	5	16	11	18	3
2½×14	12	18	2	18	10	19	6	20	1	21	7
2½×14	16	16	8	17	3	17	10	18	4	19	9
3×14	12	19	4	20	1	20	8	21	4	22	11
3×14	16	17	7	18	3	18	10	19	4	20	10

*E is the modulus of elasticity and is in pounds per square inch.

TABLE XXX.

MAXIMUM SPAN FOR FLOOR-JOISTS FOR RETAIL STORES.

Total load, 174 pounds per square foot.

Sizes of joists.	Dist. on centers.	Hemlock. At 600 lbs. per sq. in. *$A=33\frac{1}{3}$.		White pine, spruce. At 700 lbs. per sq. in. $A=38.88$.		Norway pine, Douglas fir. At 800 lbs. per sq. in. $A=44.44$.		Southern short-leaf yellow pine. At 1,000 lbs. per sq. in. $A=55.55$.		Southern long-leaf yellow pine At 1,200 lbs. per sq. in. $A=66\frac{2}{3}$.	
ins.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.
3×8	12	8	7	9	3	9	11	11	1	12	2
3×8	16	7	5	8	0	8	7	9	7	10	6
2×10	12	8	9	9	5	10	1	11	4	12	5
2×10	16	7	7	8	2	8	9	9	10	10	9
3×10	12	10	9	11	7	12	5	13	10	15	2
3×10	16	9	3	10	0	10	9	12	0	13	2
2×12	12	10	6	11	4	12	2	13	7	14	10
2×12	16	9	1	9	10	10	6	11	9	12	10
Total load, 177 pounds per square foot.											
3×12	12	12	6	13	6	14	6	16	2	17	9
3×12	16	10	10	11	9	12	6	14	0	15	4
2×14	12	12	2	13	1	14	0	15	8	17	2
2×14	16	10	6	11	4	12	2	13	7	14	11
2½×14	12	13	7	14	8	15	8	17	6	19	2
2½×14	16	11	9	12	8	13	7	15	2	16	8
3×14	12	16	8	18	0	19	3	21	6	23	7
3×14	16	14	5	15	7	16	8	18	8	20	5

*A in Tables XXX and XXXI is the coefficient for beams and is one-eighteenth of the allowable fiber-stress. For values of A for other woods, see Table XII.

TABLE XXXI.*

Maximum Span for Rafters. *A*. Shingled Roofs, not Plastered.

Total load, 48 pounds per square foot.

Sizes of joists.	Dist. on centers.	Hemlock. At 600 lbs. per sq. in. †$A=33\frac{1}{3}$.		White pine, spruce. At 700 lbs. per sq. in. $A=38.88$.		Norway pine Douglas fir. At 800 lbs. per sq. in. $A=44.44$.		Southern short-leaf yellow pine. At 1,000 lbs. per sq. in. $A=55.55$.		Southern long-leaf yellow pine At 1,200 lbs. per sq. in. $A=66\frac{2}{3}$.	
ins.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.
2×4	16	5	9	6	3	6	8	7	5	8	2
2×4	20	5	2	5	7	5	11	6	8	7	4
2×6	16	8	8	9	4	10	0	11	2	12	3
2×6	20	7	9	8	4	8	11	10	0	10	11
3×6	16	10	7	11	5	12	3	13	8	15	0
3×6	20	9	6	10	3	10	11	12	3	13	5
2×8	16	11	6	12	6	13	4	14	11	16	4
2×8	20	10	4	11	2	11	11	13	4	14	7
2×8	24	9	5	10	2	10	11	12	2	13	4
2×10	16	14	5	15	7	16	8	18	8	20	5
2×10	20	12	11	13	11	14	11	16	8	18	3
2×10	24	11	9	12	9	13	7	15	2	16	8

TABLE XXXI (*Continued*).

Maximum Span for Rafters. *B*. Slate Roofs, not Plastered, or Shingle Roofs, Plastered.

Total load, 57 pounds per square foot.

Sizes of joists.	Dist. on centers.	Hemlock. At 600 lbs. per sq. in. ‡$A=33\frac{1}{3}$.		White pine, spruce. At 700 lbs. per sq. in. $A=38.88$.		Norway pine, Douglas fir. At 800 lbs. per sq. in. $A=44.44$.		Southern short-leaf yellow pine. At 1,000 lbs. per sq. in. $A=55.55$.		Southern long-leaf yellow pine At 1,200 lbs. per sq. in. $A=66\frac{2}{3}$.	
ins.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.
2×4	16	5	3	5	9	6	1	6	10	7	6
2×4	20	4	9	5	1	5	6	6	1	6	8
2×6	16	7	11	8	7	9	2	10	3	11	3
2×6	20	7	1	7	8	8	2	9	2	10	1
3×6	16	9	0	10	6	11	3	12	7	13	9
3×6	20	8	8	9	5	10	1	11	3	12	4
2×8	16	10	7	11	5	12	3	13	8	15	0
2×8	20	9	6	10	3	10	11	12	3	13	5
2×8	24	8	8	9	4	10	0	11	2	12	3
3×8	16	13	0	14	0	15	0	16	9	18	4
3×8	20	11	7	12	6	13	5	15	0	16	4
3×8	24	10	7	11	5	12	3	13	8	15	0
2×10	16	13	3	14	4	15	3	17	1	18	9
2×10	20	11	10	12	9	13	8	15	3	16	9
2×10	24	10	10	11	8	12	6	13	11	15	3

*Tables XXXI, *A*, *B* and *C* are intended for climates where a snow-fall of two feet may be expected. In the southern states, where there is very little snow, the spans in Table *A* will be safe for slate or gravel roofs if the joists are sawed to the full dimensions.

†‡See, also, footnote with Table XXX.

TABLE XXXI (*Continued*).

MAXIMUM SPAN FOR RAFTERS. *C.* SLATE ROOFS, PLASTERED, OR GRAVEL ROOFS, NOT PLASTERED.

Total load, 66 pounds per square foot.

Sizes of joists.	Dist. on centers.	Hemlock. At 600 lbs. per sq. in. *$A=33\frac{1}{3}$.		White pine, spruce. At 700 lbs. per sq. in. $A=38.88$.		Norway pine, Douglas fir. At 800 lbs. per sq. in. $A=44.44$.		Southern short-leaf yellow pine. At 1,000 lbs. per sq. in. $A=55.55$.		Southern long-leaf yellow pine At 1,200 lbs. per sq. in. $A=66\frac{2}{3}$.	
ins.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.
2× 6	16	7	5	8	0	8	6	9	6	10	5
2× 6	20	6	7	7	2	7	7	8	6	9	4
3× 6	16	9	0	9	9	10	5	11	8	12	10
3× 6	20	8	1	8	9	9	4	10	5	11	5
2× 8	16	9	1)	10	8	11	4	12	8	13	11
2× 8	20	8	10	9	6	10	2	11	4	12	5
2× 8	24	8	0	8	8	9	3	10	5	11	4
3× 8	16	12	1	13	0	13	11	15	7	17	1
3× 8	20	10	9	11	8	12	5	13	11	15	3
3× 8	24	9	10	10	8	11	4	12	8	13	11
2×10	16	12	4	13	3	14	2	15	11	17	5
2×10	20	11	0	11	11	12	9	14	2	15	7
2×10	24	10	1	10	10	11	10	13	0	14	2
2×12	16	14	9	15	11	17	1	19	1	20	11
2×12	20	13	2	14	3	15	3	17	1	18	8
2×12	24	12	1	13	0	13	11	15	7	17	1

*See, also, footnote with Table XXX.

9. THE STRENGTH OF WOODEN COLUMNS.

For wooden columns in buildings used for ordinary purposes, when the length in inches does not exceed twelve times the least thickness, the safe strength of the column may be obtained by multiplying its sectional area in square inches by 1,000 for long-leaf yellow pine and white oak, 900 for Douglas fir and spruce, and 800 for white pine. For machinery or full permanent loads, such as brick or stone walls, these values should be reduced one-fifth.

The safe load for a column whose length in inches exceeds twelve times its least dimensions may be computed by means of the following table, allowing four-fifths for Douglas fir, spruce and eastern fir; three-fourths for white pine, short-leaf yellow pine, hemlock and chestnut; and five-eighths for Norway pine, cypress, cedar, poplar and California redwood:

TABLE XXXV.

PROPERTIES OF WOODS. AVERAGE ULTIMATE UNIT STRESSES

B. BROAD-LEAVED OR HARD WOODS.

Kinds of wood.	Weight per cu. ft. dry, lbs.	Strength, in lbs. per sq. in.				Shear, lbs. per sq. in.	
		Tension.	Compression.		Bending (modulus of rupture).	With the grain.	Across the grain.
			With the grain.	Across the grain.			
Ash (white)	40 77	11,000 to 17,000	4,000 to 9,000	1,900	6,300 to 14,200	450 to 1,100	6,280
Ash (red)	38 96	....	6,800	.....	.....	....	...
Ash (green)	44 35	....	8,000 to 9,800	1,700	5,100 to 16,000	1,000	6,280
Cedar (Central America)	.....	5,000 to 9,000	4,814	..	1,100 to 1,900	....	3,410
Chestnut	41.00	9,000 to 13,000	5,000	900	5,000	600	1,500
Elm (white)	45.26	8,000 to 13,000	6,000 to 10,000	1,200	7,300 to 13,600	800	.....
Gum	36.83	15,000 to 18,000	5,600 to 8,500	1,400	6,000 to 12,700	800	5,890
Hickory	46.16 to 52.17	12,800 to 18,000	7,000 to 10,000	2,700 to 3,200	5,400 to 24,300	1,000 to 1,200	6,000 to 7,800
Locust	45 70	10,500 to 24,800	7,000 to 11,700	...	......	......	7,176
Lignum vitae	71.24 to 83 00	10,000 to 12,000	8,000 to 9,600	.....	......	......	......
Maple (hard)	43 06	8,000 to 10,000	7,000 to 9,940	....	......	......	6,356
Maple (white)	32 84	8,000 to 10,000	6,000 to 7,500	1,700 to 1,900	......	390 to 537	6,355
Mahogany (Central America)	35 00	2,300 to 17,900	6,000	......	10,800	.....	.....
Oak (white)	46 35	10,000 to 19,500	4,500 to 11,300	2,000	6,000	750 to 1,000	4,425
Oak (chestnut)	53 63	10,000	7,500	.	...	......	..
Oak (live)	59 21	10,000 to 16,380	8,000 to 10,000	....	......	.....	8,480

TABLE XXXV * (*Continued*).

PROPERTIES OF WOODS. AVERAGE ULTIMATE UNIT STRESSES.
B. BROAD-LEAVED OR HARD WOODS.

Kinds of wood.	Weight per. cu. ft. dry, lbs.	Strength, in lbs. per sq. in.				Shear, lbs. per. sq. in.	
		Tension.	Compression.		Bending (modulus of rupture).	With the grain.	Across the grain.
			With the grain.	Across the grain.			
Oak (red and black)	40.75	10,000	4,000 to 8,500	2,300	9,100 to 15,400	1,100	......
Poplar (whitewood)	30.00	7,000	4,000 to 5,700	......	......	......	4,418
Walnut (white) (butternut)..........	25.46	......	5,000 to 6,800	......	......	......	2,830
Walnut (black).....	38.11	9,000 to 16,000	7,500	......	......	......	4,728

*The higher values of tensile and compressive strengths are for "dry" or "seasoned" timber containing from 10 to 15 per cent of water.

TABLE XXXVI.*

SAFE ALLOWABLE WORKING† UNIT STRESSES FOR WOODS, IN POUNDS PER SQUARE INCH.

Kinds of wood.	Tension.		Compression.			Transverse.		Shear.‡	
	With the grain.	Across the grain.	With the grain.		Across the grain.	Extreme fiber-stress.	Modulus of elasticity. $E/1000$	With the grain.	Across the grain.
			End-bearing.	Cols. under 15 diams.					
Factor of safety.	Ten.	Ten.	Five.	Five.	Four.	Six.	One.	Four.	Four.
White oak....	1,200	200	1,400	1,000	500	1,200	1,500	200	1,000
White pine....	700	50	1,100	800	200	700	1,000	100	500
Southern long-leaf pine ..	1,200	60	1,400	1,000	350	1,200	1,500	150	1,250
Douglas fir....	800	...	1,200	900	200	800	1,500	130	900
Short-leaf yellow pine....	900	50	1,100	800	250	1,000	1,200	130	1,000
Red pine or Norway pine	800	50	1,000	750	200	800	1,100	125	750
Spruce and eastern fir...	800	50	1,200	900	200	700	1,200	100	750
Hemlock......	600	...	1,100	800	150	600	900	100	600
Cypress.......	600	...	1,000	750	200	800	900	125	....
Cedar........	700	...	1,100	750	200	700	700	100	500
Chestnut.....	850	...	....	800	250	800	1,000	150	500
California redwood.......	700	...	900	800	150	750	700	75	....

Note.—For footnotes see bottom of page 827.

TABLE XXXVII. PERMISSIBLE UNIT STRESSES FOR WOODS, IN POUNDS PER SQUARE INCH. FROM BUILDING LAWS OF CITIES.

Kinds of stress.	Kind of wood.	New York.*	Chicago.	Baltimore.§	Boston.¶
Tension.	Yellow pine†....	1,200	1,300	1,800LLYP	....
	White pine.....	800	800	1,000	....
	Spruce‡.......	800	800	1,200	....
	Hemlock.......	600	600	800	....
	Chestnut.......	....	....	....	....
	Oak...........	1,000	1,200	1,500	....
	Locust.........	....	....	....	....
			1,000SLYP‖	1,200VP	
Compression with the grain.	Yellow pine†....	1,000	1,110	1,000LLVP	....
	White pine.....	800	700	800	....
	Spruce‡........	800	700	800	....
	Hemlock.......	500	500	600	....
	Chestnut.......	500	....	....	....
	Oak...........	900	900	1,000	....
	Locust.........	1,200	....	1,200	....
			800SLYP‖	800NCorYP	
Compression across the grain.	Yellow pine† ...	600	250	600LLYP	500
	White pine	400	200	400	250
	Spruce‡........	400	200	400	250
	Hemlock.......	500	150	500	....
	Chestnut.......	1,000	....	....	....
	Oak...........	800	500	600	600
	Locust.........	1,000	....	1,000	....
			250SLYP‖	400NCorVP	
Transverse bending.	Yellow pine†....	1,200	1,300	1,800LLYP	1,500
	White pine.....	800	800	1,000	1,000
	Spruce‡........	800	800	1,350	1,000
	Hemlock.......	600	600	1,000	....
	Chestnut.......	800	....	....	....
	Oak...........	1,000	1,200	1,500	1,000
	Locust.........	1,200	....	....	....
			1,000SLYP‖		
Shear with the grain.	Yellow pine†....	70	130	100LLYP	100
	White pine.....	40	80	85	80
	Spruce‡........	50	80	90	80
	Hemlock.......	40	60	75	....
	Chestnut.......	....	....	....	....
	Oak...........	100	200	100	150
	Locust.........	100	....	....	....
			120SLYP‖	90VP	
Shear across the grain.	Yellow pine†....	500	....	500LLYP	....
	White pine.....	250	....	350	....
	Spruce‡........	320	....	350	....
	Hemlock.......	275	....	350	....
	Chestnut.......	150	....	150	....
	Oak...........	600	....	720	....
	Locust........	720	....	....	....
				400VP	

*Stresses named by New York, Cincinnati, District of Columbia and the Board of Fire Underwriters are generally identical, with the following exceptions: District of Columbia omits hemlock, omits chestnut in shear across grain and puts spruce and Virginia pine under one caption; Cincinnati makes caption of white pine and spruce, with New York white-pine values, and gives 270 for hemlock, for shear across the grain.

†In Chicago, "Douglas fir and long-leaf yellow pine."

‡In Chicago, no values for spruce, but spruce-values given apply to Norway pine.

‖In Chicago, values are given for short-leaf yellow pine, SLYP.

§In Baltimore, LLYP for long-leaf yellow pine and NC or VP for North Carolina or Virginia pine.

¶In Boston, yellow pine is written, "yellow pine (longleaf)."

TABLE XXXVIII.*

Safe Working-Stresses in Tension for Some Metals and Woods.

Materials.	Safe stress, lbs. per sq. in.
Cast iron (New York City)	3,000
Wrought iron	12,000
Steel, medium	16,000
Chestnut	850
Hemlock (New York City)	600
Pine, long-leaf yellow	1,200
Pine, Norway	800
Pine, white	700
Douglas fir	800
Redwood	700
Spruce	800

*Except where noted, the above values are in accordance with the recommendations of the Association of Railway Superintendents.

The stresses for woods are for unseasoned timber and may be increased 30 per cent for protected timber not subjected to impact, as in buildings. For safe, working, tensile stresses of other woods, see Table XXXVI.

TABLE XXXIX.*

Safe Working-Stresses in Compression for Some Metals and Woods.

Materials.	Safe stress, lbs. per sq. in.
Cast iron (in short blocks)	16,000
Wrought iron	12,000
Rolled steel	16,000
Cast steel	16,000
Steel pins and rivets (bearing)	20,000
Wrought-iron pins and rivets (bearing)	15,000
White oak (short pieces, end-bearing)	1,400
White pine (short pieces, end-bearing)	1,100
Long-leaf yellow pine (short pieces, end-bearing)	1,400
Short-leaf yellow pine (short pieces, end-bearing)	1,100
Douglas fir (short pieces, end-bearing)	1,200

*The stresses for the woods are for unseasoned timber and may be increased 30 per cent for protected timber not subjected to impact, as in buildings. For safe, working, compressive stresses of other woods and for short columns, see Table XXXVI.

TABLE XL.*

Safe Working-Stresses in Shear for Some Metals and Woods.

Materials.	Safe stress, lbs. per sq. in.	
Cast iron (New York City)	3,000	
Wrought iron	7,500	
Steel (bolts and rivets)	10,000	
	With the grain.	Across the grain
White oak	200	1,000
White pine	100	500
Long-leaf yellow pine	150	1,250
Short-leaf yellow pine	130	1,000
Douglas fir	130	900
Hemlock (New York City)	40	275
Spruce (New York City)	50	320

Except where noted, the above values are in accordance with the recommendations of the Association of Railway Superintendents.

*The stresses for the woods are for unseasoned timber and may be increased 30 per cent for protected timber not subjected to impact, as in buildings. For safe, working, shearing stresses of other woods, see Table XXXVI.

TABLE XLI.* Safe Working-Stresses in Bending for Extreme Fibers for Some Metals and Woods.

Materials.	Safe stresses, lbs. per sq. in.
Cast iron (tension side)	3,000
Cast iron (compression side)	16,000
Wrought iron (rolled beams)	12,000
Wrought iron (pins, rivets and bolts)	15,000
Wrought iron (riveted beams, net flange-section)	12,000
Steel (rolled beams)	16,000
Steel (rolled pins, rivets and bolts)	20 000
Steel (riveted beams, net flange section)	14,000
White oak	1,200
White pine	700
Long-leaf yellow pine	1,200
Short-leaf yellow pine	1,000
Douglas fir	800
Hemlock	600
Spruce	700
Slate	400
Bluestone flagging	305
Granite (average)	180
Gneiss (New York City)	150
Limestone	145
Marble	125
Sandstone	110
Brick (common)	50
Concrete (Portland-cement) 1:2:4	30
Concrete (Portland-cement) 1:2:5	20
Concrete (natural cement) 1:2:4	16
Concrete (natural cement) 1:2:5	10

*The stresses for the woods are for unseasoned timber and may be increased 30 per cent for protected timber not subjected to impact, as in buildings. For safe, working, bending fiber-stresses of other woods, see Table XXXVI.

12. BOARD-MEASURE.*

TABLE XLII.

Equivalents in Board-Measure for Different Dimensions.

Size in inches.	Length in feet. 10	12	14	16	18	20	22	24	26	28	30	32
2×4	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16	17⅓	18⅔	20	21⅓
2×6	10	12	14	16	18	20	22	24	26	28	30	32
2×8	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32	34⅔	37⅓	40	42⅔
2×10	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40	43⅓	46⅔	50	53⅓
2×12	20	24	28	32	36	40	44	48	52	56	60	64
2×14	23⅓	28	32⅔	37⅓	42	46⅔	51⅓	56	60⅔	65⅓	70	74⅔
2×16	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64	69⅓	74⅔	80	85⅓
2½×12	25	30	35	40	45	50	55	60	65	70	75	80
2½×14	29⅙	35	40⅚	46⅔	52½	58⅓	64⅙	70	75⅚	81⅔	87½	93⅓
2½×16	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80	86⅔	93⅓	100	106⅔
3×6	15	18	21	24	27	30	33	36	39	42	45	48
3×8	20	24	28	32	36	40	44	48	52	56	60	64
3×10	25	30	35	40	45	50	55	60	65	70	75	80
3×12	30	36	42	48	54	60	66	72	78	84	90	96
3×14	35	42	49	56	63	70	77	84	91	98	105	112
3×16	40	48	56	64	72	80	88	96	104	112	120	128
4×4	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32	34⅔	37⅓	40	42⅔
4×6	20	24	28	32	36	40	44	48	52	56	60	64
4×8	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64	69⅓	74⅔	80	85⅓
4×10	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80	86⅔	93⅓	100	106⅔
4×12	40	48	56	64	72	80	88	96	104	112	120	128
4×14	46⅔	56	65⅓	74⅔	84	93⅓	102⅔	112	121⅓	130⅔	140	149⅓
6×6	30	36	42	48	54	60	66	72	78	84	90	96
6×8	40	48	56	64	72	80	88	96	104	112	120	128
6×10	50	60	70	80	90	100	110	120	130	140	150	160
6×12	60	72	84	96	108	120	132	144	156	168	180	192
6×14	70	84	98	112	126	140	154	168	182	196	210	224
6×16	80	96	112	128	144	160	176	192	208	224	240	256
8×8	53⅓	64	74⅔	85⅓	96	106⅔	117⅓	128	138⅔	149⅓	160	170⅔
8×10	66⅔	80	93⅓	106⅔	120	133⅓	146⅔	160	173⅓	186⅔	200	213⅓
8×12	80	96	112	128	144	160	176	192	208	224	240	256
8×14	93⅓	112	130⅔	149⅓	168	186⅔	205⅓	224	242⅔	261⅓	280	298⅔
10×10	83⅓	100	116⅔	133⅓	150	166⅔	183⅓	200	216⅔	233⅓	250	266⅔
10×12	100	120	140	160	180	200	220	240	260	280	300	320
10×14	116⅔	140	163⅓	186⅔	210	233⅓	256⅔	280	303⅓	326⅔	350	373⅓
10×16	133⅓	160	186⅔	213⅓	240	266⅔	293⅓	320	346⅔	373⅓	400	426⅔
12×12	120	144	168	192	216	240	264	288	312	336	360	384
12×14	140	168	196	224	252	280	308	336	364	392	420	448
12×16	160	192	224	256	288	320	352	384	416	448	480	512
14×14	163⅓	196	228⅔	261⅓	294	326⅔	359⅓	392	424⅔	457⅓	490	522⅔
14×16	186⅔	224	261⅓	298⅔	336	373⅓	410⅔	448	485⅓	522⅔	560	597⅓

*All rough lumber is sold by the foot, "board-measure," one foot, board-measure, being the equivalent to a board one foot wide, one foot long and one inch thick.

13. THE TENSILE STRENGTH OF ROUND RODS.

TABLE XLIII.

SAFE LOADS FOR ROUND RODS.

Diameters in inches.	Plain rods. Loads in pounds based on area at root of thread. Stresses in pounds per square inch. At 10,000 lbs. per sq. in.	Plain rods. At 12,000 lbs. per sq. in.	Plain rods. At 16,000 lbs. per sq. in.	Upset rods. Loads in pounds based on full area of rod. Stresses in pounds per square inch. At 10,000 lbs. per sq. in.	Upset rods. At 12,000 lbs. per sq. in.	Upset rods. At 16,000 lbs. per sq. in.
1/4	270	324	432	491	590	785
5/16	450	540	720	767	920	1,230
3/8	680	816	1,088	1,104	1,320	1,770
7/16	930	1,116	1,488	1,503	1,800	2,400
1/2	1,260	1,513	2,016	1,963	2,360	3,140
9/16	1,620	1,944	2,952	2,485	2,970	3,960
5/8	2,020	2,424	3,232	3,068	3,680	4,910
3/4	3,020	3,624	4,832	4,418	5,300	7,070
7/8	4,200	5,040	6,720	6,013	7,210	9,620
1	5,500	6,600	8,800	7,854	9,420	12,570
1 1/8	6,940	8,328	11,104	9,940	11,930	15,900
1 1/4	8,930	10,716	14,288	12,270	14,720	19,630
1 3/8	10,570	12,680	16,910	14,840	17,810	23,750
1 1/2	12,950	15,540	20,720	17,670	21,200	28,270
1 5/8	15,150	18,180	24,240	20,730	24,880	33,170
1 3/4	17,440	20,930	27,900	24,050	28,860	38,480
1 7/8	20,480	24,580	32,760	27,610	33,130	44,180
2	23,020	27,620	36,830	31,420	37,700	50,270
2 1/8	26,340	31,610	42,150	35,460	42,550	56,640
2 1/4	30,230	36,280	48,370	39,760	47,710	63,600
2 3/8	33,000	39,600	52,800	44,300	53,160	70,880
2 1/2	37,150	44,580	59,440	49,080	58,900	78,530
2 3/4	46,190	55,430	73,900	59,390	71,270	95,020
3	54,280	65,140	86,850	70,680	84,820	113,090
3 1/4	65,100	78,120	104,160	82,950	99,540	132,720
3 1/2	75,480	90,570	120,770	96,210	115,450	153,840
3 3/4	86,410	103,690	138,250	110,450	132,540	176,690
4	99,930	119,920	159,890	125,660	150,790	201,050
4 1/4	113,290	135,900	181,300	141,800	170,160	226,880
4 1/2	127,430	152,900	203,900	159,000	190,800	254,400
4 3/4	142,200	170,600	227,500	177,200	212,640	283,520
5	157,630	189,100	252,200	196,300	235,560	314,080
5 1/4	175,720	210,800	281,100	216,400	259,680	346,200
5 1/2	192,670	231,200	308,300	237,500	285,000	380,000
5 3/4	212,620	255,100	340,200	259,600	311,000	414,700
6	230,980	277,200	369,600	282,700	339,200	452,300

14. THE STRENGTH OF CAST-IRON COLUMNS.

Short columns of cast iron, with a length in inches not exceeding eight times their least dimension, may be safely loaded with about five tons for each square inch of metal in the cross-section.

The safe load for longer columns should be computed by means of accepted formulas. These formulas vary for different forms of cross-section; they may be found in most books of reference. The following tables give the breaking and safe loads per square inch and the safe loads for cast-iron columns with hollow circular, square and rectangular cross-sections and with varying thicknesses of shell. The caps and bases are described in Art. 461.

TABLE XLIV.

STRENGTH PER SQUARE INCH OF HOLLOW, ROUND AND RECTANGULAR CAST-IRON COLUMNS.

Length in inches divided by external breadth or diameter.	Breaking-weight in pounds per square inch.		Safe load in pounds per square inch. Factor of safety, 8.	
	Round.	Rectangular.	Round.	Rectangular.
8	74,074	75,470	9,259	9,433
9	72,661	74,350	9,082	9,293
10	71,110	73,126	8,888	9,140
11	69,505	71,870	8,688	8,983
12	67,800	70,487	8,475	8,811
13	66,060	69,084	8,257	8,635
14	64,257	67,567	8,032	8,446
15	62,450	66,060	7,806	8,257
16	60,606	64,516	7,576	8,064
17	58,780	62,942	7,347	7,867
18	56,940	61,360	7,117	7,670
19	55,134	59,745	6,892	7,468
20	53,333	58,180	6,666	7,272
21	51,580	56,610	6,447	7,076
22	49,843	55,020	6,230	6,877
23	48,163	53,470	6,020	6,684
24	46,512	51,950	5,814	6,494
25	44,918	50,440	5,614	6,305
26	43,360	48,960	5,420	6,120
27	41,862	47,530	5,233	5,940
28	40,404	46,110	5,050	5,764
29	39,000	44,742	4,875	5,592
30	37,647	43,390	4,706	5,424
31	36,347	42,080	4,543	5,260
32	35,090	40,816	4,386	5,102
33	33,884	39,580	4,235	4,947
34	32,720	38,380	4,090	4,797
35	31,603	37,244	3,951	4,655
36	30,534	36,120	3,817	4,515

TABLE XLV. Safe Load in Tons of 2,000 Pounds for Hollow Round Cast-Iron Columns with Square Ends.

Diam. in inches.	Thickness in inches.	Length of column in feet.										Area of metal in inches.	Weight per foot of length.
		6	8	10	12	14	16	18	20	22	24		
5	¾	39	34	29	24	....	....	....	....	....	....	10.0	31.3
	⅞	45	38	32	27	....	....	....	....	....	....	11.3	35.3
5½	¾	46	40	35	30	26	....	....	....	....	....	11.2	35.0
	⅞	52	46	40	34	29	....	....	....	....	....	12.7	39.7
6	¾	52	47	41	36	31	27	24	....	....	....	12.4	38.7
	⅞	60	53	47	41	36	31	27	....	....	....	14.1	44.0
	1	66	59	52	45	39	34	30	....	....	....	15.7	49.0
7	¾	65	60	54	48	43	38	34	....	....	....	14.7	46.0
	⅞	74	68	62	55	49	43	38	....	....	....	16.8	52.6
	1	83	76	68	61	54	48	43	....	....	....	18.8	58.9
8	¾	78	72	67	61	55	50	45	40	36	33	17.1	53.4
	⅞	89	83	76	70	63	57	51	46	41	37	19.6	61.2
	1	100	93	86	79	71	64	58	52	47	42	22.0	68.7
9	⅞	103	98	91	85	80	71	65	59	54	49	22.3	69.8
	1	117	110	103	95	90	80	773	67	61	55	25.1	78.5
	1⅛	129	122	114	105	99	89	81	74	67	61	27.8	87.0
10	⅞	118	112	106	100	93	86	79	73	67	62	25.1	78.4
	1	133	127	120	112	105	97	89	82	76	69	28.3	88.4
	1⅛	147	141	133	125	116	107	99	91	84	77	31.4	98.0
	1¼	161	154	146	136	127	118	109	100	92	84	34.4	107.4
11	1	149	143	137	129	122	114	106	98	91	85	31.4	98.2
	1⅛	165	159	152	144	135	126	118	109	101	94	34.9	109.1
	1¼	182	175	167	158	148	139	129	120	111	103	38.3	119.7
	1⅜	197	190	181	171	161	151	140	130	121	112	41.6	129.9
12	1⅛	184	178	171	163	154	146	137	128	120	112	38.4	120.1
	1¼	202	195	188	179	170	160	150	141	132	123	42.2	131.9
	1⅜	220	212	204	194	184	174	163	153	143	133	45.9	143.4
	1½	237	220	220	210	199	187	176	165	154	144	49.5	154.6
13	1⅛	202	196	190	182	174	165	156	147	138	130	42.0	131.2
	1¼	222	216	209	200	191	181	172	162	152	143	46.1	144.2
	1⅜	242	235	227	218	203	197	187	176	166	156	50.2	156.9
	1½	261	254	245	235	224	213	201	190	179	168	54.2	169.4
14	1¼	242	236	229	221	212	203	193	183	173	164	50.1	156.5
	1⅜	264	258	250	241	231	221	210	199	189	178	54.5	170.4
	1½	285	278	270	260	250	238	227	215	204	193	58.9	184.1
	1⅝	306	298	289	279	268	256	243	231	219	207	63.2	197.4
15	1⅜	268	280	272	264	254	244	234	223	212	203	58.9	183.9
	1½	309	303	295	285	275	264	252	241	229	219	63.6	203.4
	1⅝	332	325	316	306	295	283	271	259	246	235	68.3	213.4
	1¾	354	346	337	327	315	302	288	276	263	251	72.8	227.6
16	1½	333	327	319	310	300	290	278	267	255	243	68.3	213.5
	1⅝	358	351	343	333	322	311	299	286	273	261	73.4	229.3
	1¾	382	375	366	356	344	332	319	306	292	279	78.3	244.8
	1⅞	455	446	435	423	410	395	380	364	347	332	93.2	291.3

TABLE XLVI.

SAFE LOAD IN TONS OF 2,000 POUNDS FOR HOLLOW SQUARE AND RECTANGULAR CAST-IRON COLUMNS WITH SQUARE ENDS.

Size in inches.	Thickness in inches.	Length of column in feet. 8	10	12	14	16	18	20	24	Area of metal in inches.	Weight per foot of length.
4×6	¾	41	34	28	....	....	....	....	....	12.75	39.8
4×8	¾	51	42	35	....	....	....	....	....	15.75	49.2
4×9	¾	56	46	39	....	....	....	....	....	17.25	53.9
4×10	¾	60	50	42	....	....	....	....	....	18.75	58.6
4×12	¾	70	59	49	....	....	....	....	....	21.75	68.0
5×8	¾	64	55	48	41	....	....	....	....	17.25	53.9
	1	81	71	61	53	....	....	....	....	22.00	68.8
5×9	¾	69	60	52	45	....	....	....	....	18.75	58.6
	1	89	78	67	58	....	....	....	....	24.00	75.0
5×10	¾	75	65	57	49	....	....	....	....	20.25	63.3
	1	96	84	73	63	....	....	....	....	26.00	81.3
5×12	¾	86	74	65	56	....	....	....	....	23.25	72.7
	1	111	97	84	72	....	....	....	....	30.00	93.8
6×6	¾	63	57	51	45	40	35	....	....	15.75	49.2
	1	80	72	65	57	51	45	....	....	20.00	62.5
6×8	¾	75	68	60	54	47	42	....	....	18.75	58.6
	1	96	87	78	69	61	54	....	....	24.00	75.0
6×9	¾	81	73	65	58	51	45	....	....	20.25	63.3
	1	104	94	84	75	66	58	....	....	26.00	81.3
6×10	¾	87	79	70	62	55	49	....	....	21.75	68.0
	1	112	101	91	80	71	63	....	....	28.00	87.5
6×12	¾	99	90	80	71	63	55	....	....	24.75	77.3
	1	129	116	104	92	81	72	....	....	32.00	100.0
6×15	¾	117	106	95	84	74	66	....	....	29.25	91.4
	1	153	138	123	109	97	85	....	....	38.00	118.8
7×7	¾	80	73	67	61	55	49	44	....	18.75	58.6
	1	102	94	85	78	70	63	57	....	24.00	75.0
7×9	¾	92	85	77	70	63	57	51	....	21.75	68.0
	1	119	109	100	91	82	74	66	....	28.00	87.5
7×12	¾	111	102	93	85	77	69	62	....	26.25	82.0
	1	144	133	121	110	99	89	80	....	34.00	106.3
8×8	¾	95	90	83	77	70	64	59	49	21.75	68.0
	1	124	115	107	99	91	83	76	63	28.00	87.5
	1¼	148	140	129	119	109	100	91	76	33.75	105.5
8×10	¾	109	103	95	87	80	73	67	55	24.75	77.3
	1	141	132	122	113	104	95	86	72	32.00	100.0
	1¼	170	161	148	137	125	115	105	87	38.75	121.1
8×12	¾	122	115	106	98	90	82	75	62	27.75	86.7
	1	158	148	138	127	116	107	97	81	36.00	112.5
	1¼	192	181	167	154	142	130	118	98	43.75	136.7
8×16	1	193	181	168	155	142	130	119	99	44.00	137.5
	1¼	236	221	206	190	174	159	145	121	53.75	168.0
9×9	¾	111	106	99	93	83	80	74	63	24.75	77.3

TABLE XLVI (*Continued*).

SAFE LOAD IN TONS OF 2,000 POUNDS FOR HOLLOW SQUARE AND RECTANGULAR CAST-IRON COLUMNS WITH SQUARE ENDS.

Size in inches.	Thickness in inches.	Length of column in feet.								Area of metal in inches.	Weight per foot of length.
		8	10	12	14	16	18	20	24		
	1	144	137	129	120	112	103	96	85	32.00	100.0
9×12	1	171	162	153	143	133	123	114	97	38.00	118.8
	1¼	209	198	186	174	162	149	138	118	46.25	144.5
9×16	1	207	196	185	173	161	149	138	117	46.00	143.8
	1¼	254	240	226	212	197	182	168	143	56.25	175.8
10×10	1	165	158	150	142	133	125	117	101	36.00	112.5
	1¼	201	193	183	172	162	152	142	123	43.75	136.7
10×12	1	184	176	167	158	148	139	129	112	40.00	125.0
	1¼	224	214	204	192	181	169	158	137	48.75	152.3
10×15	1	211	202	192	181	170	160	149	129	46.00	143.8
	1¼	258	247	235	222	209	195	182	158	56.25	175.8
10×16	1	220	211	200	189	178	167	155	135	48.00	150.0
	1¼	270	258	245	232	218	204	190	165	58.75	183.6
10×18	1	239	228	217	205	193	181	168	146	52.00	162.5
	1¼	293	280	266	251	236	221	207	179	63.75	199.2
10×20	1	257	246	234	221	208	194	181	157	56.00	175.0
	1¼	316	302	287	271	255	239	223	193	68.75	214.9
10×24	1	294	281	267	252	237	222	207	180	64.00	200.0
	1¼	362	346	329	311	292	274	255	221	78.75	246.1
12×12	⅞	183	177	171	164	156	149	141	126	38.90	121.7
	1	207	201	193	185	177	168	159	142	44.00	137.5
	1¼	253	245	236	223	216	206	195	174	53.75	168.0
	1½	296	288	277	265	253	241	228	204	63.00	196.9
12×15	1	235	228	220	211	201	191	181	162	50.00	156.3
	1¼	288	280	269	258	246	234	222	198	61.25	191.4
12×16	1	245	237	228	219	209	199	188	168	52.00	162.5
12×18	1	263	256	246	236	225	214	203	181	56.00	175.0
12×20	1	282	274	264	253	241	229	217	194	60.00	187.5
12×24	1	320	310	299	287	274	260	246	220	68.00	212.5
14×16	1	268	261	254	246	238	229	219	200	56.00	175.0
14×20	1	307	298	290	281	272	261	250	228	64.00	200.0
14×24	1	345	336	326	316	306	294	280	257	72.00	225.0
16×16	1	300	284	278	271	264	256	247	229	60.00	187.5
16×24	1	380	360	352	344	334	324	313	291	76.00	237.5
18×18	1	340	340	320	314	307	299	291	274	68.00	212.5
20×20	1	380	380	361	356	349	342	334	317	76.00	237.5
20×24	1	420	420	399	393	386	378	369	351	84.00	262.5

15. THE STRENGTH OF STEEL-PIPE COLUMNS.

TABLE XLVII.*

SAFE LOADS IN TONS FOR STANDARD STEEL-PIPE COLUMNS.

Lengths in feet.	Sizes of pipes.								
	2	2½	3	3½	4	4½	5	6	7
	Thickness.								
	.154	.203	.216	.226	.237	.247	.258	.280	.301
40	.....	.....	.....	.....	.....	.....	.....	.....	.....
36	.....	.....	.....	.....	.....	.....	.....	.....	19.16
33	.....	.....	.....	.....	.....	.....	.....	13.87	21.95
30	.....	.....	.....	.....	.....	.....	.....	16.47	24.74
27	.....	.....	.....	.....	.....	.....	11.16	19.06	27.53
24	.....	.....	.....	.....	.....	9.72	13.55	21.66	30.32
22	.....	.....	.....	.....	8.02	11.25	15.15	23.39	32.18
20	.....	.....	.....	6.41	9.49	12.78	16.74	25.12	34.04
18	.....	.....	.....	7.81	10.95	14.30	18.34	26.85	35.90
16	.....	.....	6.27	9.20	12.42	15.83	19.93	28.58	37.76
14	.....	4.19	7.61	10.60	13.88	17.35	21.52	30.31	39.62
13	.....	4.81	8.27	11.30	14.61	18.11	22.32	31.17	40.55
12	.....	5.44	8.94	11.99	15.34	18.88	23.12	32.04	41.48
11	2.94	6.07	9.61	12.69	16.07	19.64	23.91	32.90	42.41
10	3.42	6.69	10.27	13.39	16.81	20.40	24.71	33.77	43.34
9	3.89	7.32	10.94	14.09	17.54	21.17	25.51	34.63	44.27
8	4.37	7.94	11.60	14.78	18.27	21.93	26.30	35.50	45.20
7	4.84	8.57	12.27	15.48	19.00	22.69	27.10	36.36	46.13
6	5.32	9.20	12.94	16.18	19.73	23.45	27.90	37.23	47.06
5	5.79	9.82	13.60	16.88	20.46	24.22	28.69	38.09	47.99

*Loads in tons of 2,000 pounds. Table based on New York Building Laws
Formula used, $S = 15{,}200 - 58\, l/r$, in which
S = allowable compressive stress for steel, pounds per square inch,
l = length of column in inches,
r = least radius of gyrations in inches.
Loads above or to the left of the zig-zag lines correspond to values of l/r greater than 120.

TABLE XLVII (*Continued*).

SAFE LOADS IN TONS FOR STANDARD STEEL-PIPE COLUMNS.

Lengths in feet.	Sizes of pipes.							
	8	9	10	11	12	13	14	15
	Thickness.							
	.322	.342	.365	.375	.375	.375	.375	.375
40	24.04	33.53	45.38	55.49	64.44	75.63	84.58	93.53
36	28.02	37.76	49.90	60.12	69.07	80.26	89.21	98.17
33	31.00	40.93	53.28	63.60	72.55	83.74	92.69	101.64
30	33.99	44.10	56.66	67.08	76.03	87.22	96.17	105.12
27	36.97	47.27	60.05	70.55	79.51	90.69	99.65	108.60
24	39.96	50.44	63.43	74.03	82.98	94.17	103.12	112.08
22	41.95	52.55	65.69	76.35	85.30	96.49	105.44	114.40
20	43.94	54.66	67.94	78.67	87.62	98.81	107.76	116.71
18	45.93	56.78	70.20	80.99	89.94	101.13	110.08	119.03
16	47.92	58.89	72.46	83.30	92.26	103.45	112.40	121.35
14	49.90	61.01	74.71	85.62	94.57	105.76	114.72	123.67
13	50.90	62.06	75.84	86.78	95.73	106.92	115.88	124.83
12	51.89	63.12	76.97	87.94	96.89	108.08	117.03	125.99
11	52.89	64.18	78.10	89.10	98.05	109.24	118.19	127.15
10	53.88	65.23	79.22	90.26	99.21	110.40	119.35	128.31
9	54.88	66.29	80.35	91.42	100.37	111.56	120.51	129.47
8	55.87	67.35	81.48	92.57	101.53	112.72	121.67	130.62
7	56.87	68.40	82.61	93.73	102.69	113.88	122.83	131.78
6	57.86	69.46	83.74	94.89	103.85	115.04	123.99	132.94
5	58.86	70.52	84.86	96.05	105.00	116.20	125.15	134.10

*Loads in tons of 2,000 pounds. Table based on New York Building Laws.
Formula used, $S = 15,200 - 58\ l/r$, in which
S = allowable compressive stress for steel, pounds per square inch,
l = length of column in inches,
r = least radius of gyration in inches.
Loads above or to the left of the zigzag lines correspond to values of l/r greater than 120.

TABLE XLVIII.*

SAFE LOADS IN TONS FOR EXTRA-STRONG STEEL-PIPE COLUMNS.

Lengths in feet.	Sizes of pipes.								
	2	2½	3	3½	4	4½	5	6	7
	Thickness.								
	.218	.276	.300	.318	.337	.355	.375	.432	.500
40	....	.....	.....	.....	.....	.....	.....	.....	.....
36	....	.....	.....	.....	.....	.....	.....	.....	29.53
33	....	.....	.....	.....	.....	.....	.....	19.90	34.16
30	....	.....	.....	.....	.....	.....	.....	23.90	38.79
27	....	.....	.....	.....	.....	.....	15.22	27.90	43.42
24	....	.....	.....	.....	.....	13.10	18.69	31.89	48.04
22	....	.....	.....	.....	10.65	15.29	21.01	34.56	51.13
20	....	.....	.....	8.36	12.72	17.48	23.32	37.23	54.21
18	....	.....	.....	10.32	14.80	19.67	25.63	39.89	57.30
16	....	.....	8.14	12.28	16.88	21.86	27.95	42.56	60.38
14	....	5.25	9.99	14.24	18.95	24.05	30.26	45.22	63.47
13	....	6.09	10.91	15.22	19.99	25.14	31.42	46.55	65.01
12	....	6.94	11.84	16.20	21.03	26.24	32.57	47.89	66.55
11	3.85	7.79	12.76	17.18	22.07	27.33	33.73	49.22	68.09
10	4.52	8.64	13.68	18.16	23.11	28.43	34.89	50.55	69.64
9	5.19	9.49	14.61	19.14	24.15	29.52	36.04	51.88	71.18
8	5.86	10.34	15.53	20.12	25.19	30.61	37.20	53.22	72.72
7	6.53	11.19	16.46	21.10	26.23	31.71	38.35	54.55	74.26
6	7.20	12.03	17.38	22.08	27.26	32.80	39.51	55.88	75.80
5	7.87	12.88	18.30	23.06	28.30	33.90	40.67	57.21	77.35

*Loads in tons of 2,000 pounds. Table based on New York Building Laws.
Formula used, $S = 15,200 - 58\ l/r$, in which
S = allowable compressive stress for steel, pounds per square inch,
l = length of column in inches,
r = least radius of gyration in inches.
Loads above or to the left of the zigzag lines correspond to values of l/r greater than 120.

TABLE XLVIII (*Continued*).*

Safe Loads in Tons for Extra-Strong Steel-Pipe Columns.

Lengths in feet.	Sizes of pipes.							
	8	9	10	11	12	13	14	15
	Thickness.							
	.500	.500	.500	.500	.500	.500	.500	.500
40	35.27	47.18	60.59	72.52	84.45	99.36	111.29	123.23
36	41.44	53.36	66.77	78.70	90.63	105.54	117.47	129.41
33	46.07	57.99	71.40	83.33	95.26	110.18	122.11	134.04
30	50.70	62.62	76.04	87.97	99.90	114.81	126.75	138.68
27	55.33	67.25	80.67	92.60	104.53	119.45	131.38	143.32
24	59.96	71.88	85.30	97.23	109.17	124.08	136.02	147.95
22	63.05	74.97	88.39	100.32	112.25	127.17	139.11	151.04
20	66.13	78.06	91.48	103.41	115.34	130.26	142.20	154.13
18	69.22	81.15	94.57	106.50	118.43	133.35	145.29	157.22
16	72.31	84.23	97.66	109.59	121.52	136.44	148.38	160.31
14	75.39	87.32	100.74	112.68	124.61	139.53	151.47	163.41
13	76.94	88.87	102.29	114.22	126.16	141.08	153.01	164.95
12	78.48	90.41	103.83	115.77	127.70	142.62	154.56	166.50
11	80.02	91.95	105.38	117.31	129.25	144.17	156.10	168.04
10	81.56	93.50	106.92	118.86	130.79	145.71	157.65	169.59
9	83.11	95.04	108.47	120.40	132.34	147.26	159.19	171.13
8	84.65	96.58	110.01	121.95	133.88	148.80	160.74	172.68
7	86.19	98.13	111.56	123.49	135.43	150.35	162.29	174.22
6	87.74	99.67	113.10	125.04	136.97	151.89	163.83	175.77
5	89.28	101.22	114.64	126.58	138.52	153.44	165.38	177.31

*Loads in tons of 2,000 pounds. Table based on New York Building Laws.
Formula used, $S = 15,200 - 58\ {}^{l}/_{r}$, in which
S = allowable compressive stress for steel, pounds per square inch,
l = length of column in inches,
r = least radius of gyration in inches.
Loads above or to the left of the sigzag lines correspond to values of ${}^{l}/_{r}$ greater than 120.

TABLE XLIX.*

SAFE LOADS IN TONS FOR DOUBLE-EXTRA-STRONG STEEL-PIPE COLUMNS.

Lengths in feet.	Sizes of pipes.									
	2	2½	3	3½	4	4½	5	6	7	8
	Thickness.									
	.436	.552	.600	.636	.674	.710	.750	.864	.875	.875
40	.....	.....	.....	.....	.....	.....	.....	.....	.....	54.36
36	.....	.....	.....	.....	.....	.....	.....	.....	44.42	65.12
33	.....	.....	.....	.....	.....	.....	.....	31.65	52.47	73.18
30	.....	.....	.....	.....	.....	.....	.....	39.58	60.52	81.25
27	.....	.....	.....	.....	.....	.....	24.32	47.51	68.57	89.32
24	.....	.....	.....	.....	.....	20.74	31.19	55.43	76.62	97.38
22	.....	.....	.....	.....	16.41	25.07	35.77	60.72	81.99	102.76
20	.....	.....	.....	12.43	20.52	29.40	40.36	66.00	87.35	108.14
18	.....	.....	.....	16.30	24.62	33.74	44.94	71.28	92.72	113.51
16	.....	.....	12.47	20.16	28.73	38.07	49.52	76.57	98.09	118.89
14	.....	7.37	16.11	24.03	32.83	42.40	54.11	81.85	103.45	124.27
13	.....	9.03	17.93	25.96	34.89	44.57	56.40	84.50	106.14	126.96
12	.....	10.69	19.74	27.89	36.94	46.73	58.69	87.14	108.82	129.65
11	5.72	12.35	21.56	29.83	38.99	48.90	60.98	89.78	111.50	132.33
10	7.03	14.01	23.38	31.76	41.04	51.06	63.27	92.42	114.19	135.02
9	8.35	15.67	25.19	33.69	43.10	53.23	65.56	95.06	116.87	137.71
8	9.66	17.33	27.01	35.62	45.15	55.40	67.85	97.71	119.55	140.40
7	10.98	18.99	28.83	37.56	47.20	57.56	70.15	100.35	122.24	143.09
6	12.29	20.65	30.64	39.49	49.25	59.73	72.44	102.99	124.92	145.78
5	13.61	22.31	32.46	41.42	51.31	61.89	74.73	105.63	127.60	148.47

*Loads in tons of 2,000 pounds. Table based on New York Building Laws.
Formula used, $S = 15{,}200 - 58\ l/r$, in which
S = allowable compressive stress for steel, pounds per square inch,
l = length of column in inches,
r = least radius of gyration in inches.
Loads above or to the left of the zigzag lines correspond to values of l/r greater than 120.

TABLE XLIX (*Continued*).*

SAFE LOADS IN TONS FOR DOUBLE-EXTRA-STRONG STEEL-PIPE COLUMNS.

Lengths in feet.	Sizes of pipes.									
	2	2½	3	3½	4	4½	5	6	7	8
	Thickness.									
	.436	.552	.600	.636	.674	.710	.750	.864	.875	.875
40	.....	.....	.....	.....	.....	.....	.....	......	......	40.64
36	.....	.....	.....	.....	.....	.....	.....	......	31.86	53.61
33	.....	.....	.....	.....	.....	.....	.....	19.87	41.57	63.35
30	.....	.....	.....	.....	.....	.....	.....	29.43	51.29	73.08
27	.....	.....	.....	.....	.....	.....	16.05	39.00	61.00	82.82
24	.....	.....	.....	.....	.....	13.81	24.35	48.57	70.72	92.55
22	.....	.....	.....	.....	10.31	19.04	29.88	54.94	77.19	99.04
20	.....	.....	.....	7.13	15.27	24.27	35.41	61.32	83.67	105.53
18	.....	.....	.....	11.79	20.22	29.50	40.94	67.70	90.15	112.02
16	.....	.....	8.65	16.46	25.17	34.73	46.47	74.08	96.63	118.51
14	.....	4.17	13.03	21.12	30.13	39.95	52.00	80.46	103.10	125.00
13	.....	6.17	15.22	23.45	32.61	42.57	54.77	83.64	106.34	128.25
12	.....	8.18	17.42	25.78	35.08	45.18	57.54	86.83	109.53	131.49
11	3.78	10.18	19.61	28.12	37.56	47.80	60.30	90.02	112.82	134.74
10	5.37	12.18	21.80	30.45	40.04	50.41	63.07	93.21	116.06	137.98
9	6.96	14.19	24.00	32.78	42.52	53.02	65.83	96.40	119.29	141.23
8	8.55	16.19	26.19	35.11	44.99	55.64	68.60	99.59	122.53	144.47
7	10.13	18.20	28.38	37.45	47.47	58.25	71.36	102.78	125.77	147.72
6	11.72	20.20	30.57	39.78	49.95	60.87	74.13	105.97	129.01	149.13
5	13.31	22.21	32.77	42.11	52.42	63.48	76.89	109.15	129.89	149.13

*Loads in tons of 2,000 pounds. Based on Chicago Building Laws.
Formula used, $S = 16{,}000 - 70\ l/r$, in which
S = allowable compressive stress for steel, pounds per square inch,
l = length of column in inches,
r = least radius of gyration in inches.
Maximum allowable compressive stress = 14,000 pounds per square inch.
Loads above or to the left of the zigzag lines correspond to values of l/r greater than 120.

16. THE ADHESIVE RESISTANCE OF NAILS.

TABLE L.*

TESTS OF THE ADHESIVE RESISTANCE OF SMOOTH AND COATED NAILS.

Test Number.	Description of nails.			Length driven, inches.	Adhesive resistance, total pounds.	Average, pounds.
	Size and name.	Diameter, inches.	Total length, inches.			
	10d Common, Smooth	.145	2.99	2.50	136	
11.980	10d " "	.145	2.99	2.50	144	167
	10d " "	.145	2.99	2.50	220	
	10d Coated	.117	3.00	2.50	414	
12.058	10d "	.117	3.00	2.50	406	418
	10d "	.117	3.00	2.50	435	
	9d Common, smooth	.132	2.83	2.25	226	
11.991	9d " "	.132	2.83	2.25	125	182
	9d " "	.132	2.83	2.25	196	
	9d Coated	.114	2.68	2.25	345	
11.992	9d "	.114	2.68	2.25	318	327
	9d "	.114	2.68	2.25	317	
	8d Common, smooth	.132	2.52	2.00	146	
11.993	8d " "	.132	2.52	2.00	228	189
	8d " "	.132	2.52	2.00	192	
	8d Coated	.112	2.39	2.00	322	
12.044	8d "	.112	2.39	2.00	318	316
	8d "	.112	2.39	2.00	309	
	6d Common, Smooth	.097	2.05	1.625	100	
11.998	6d " "	.097	2.05	1.625	112	106
	6d " "	.097	2.05	1.625	105	
	6d Coated	.092	1.94	1.625	214	
12.059	6d "	.092	1.94	1.625	218	226
	6d "	.092	1.94	1.625	247	

*Report of tests made with the United States testing-machine at Watertown Arsenal, Watertown, Mass., June 30, and August 5 and 16, 1902, for the J. C. Pearson Company, Boston, Mass. All nails were driven at right-angles to the grain of the wood and all driven into the same stick.

17. POINTS THAT SHOULD BE CONSIDERED IN SELECTING OR DESIGNING JOIST-HANGERS AND WALL-HANGERS.*

Different Types of Hangers. Although wrought-iron and steel stirrups have for a long time been used for the support of floor-beams, headers and girders in buildings, no complete tests to determine their carrying-capacity appear to have been made until about three years ago [1899], when a series of tests on a common stirrup, a "Van Dorn" hanger, and a "Duplex" hanger were made at the Massachusetts Institute of Technology. Since that time other comparative tests have been made, and last November [1902], a very serious accident occurred in a large warehouse in Minneapolis, due to the failure of a steel wall-hanger of the stirrup-type. This accident and the tests above mentioned have led the writer to prepare this paper, with the view of calling attention to the danger of overlooking the tendency to fail by the bending of the hanger and the crushing of the wood in the case of hangers of the stirrup type, and, incidentally, to the comparative advantages and disadvantages of different hangers.

Before proceeding farther it will probably be well to describe the various styles of hangers now on the market.

The oldest, and, in this section of the country, the most common style of hangers, is the common stirrup, forged by hand from bar-iron or steel. The common shape of this hanger is shown in Fig. 815. Wherever the beams to be supported come directly opposite each other, it is the common practice to use a double stirrup, formed by welding together two single stirrups.

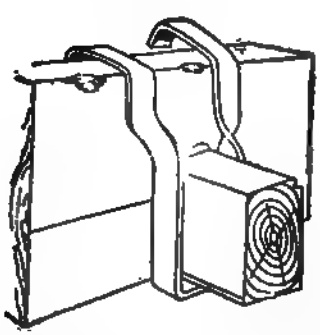


Fig. 815. Double Stirrup-Hanger, Showing Failure.

Fig. 816. The Van Dorn Hanger.

Within the past ten or twelve years, several patented forms of stirrups have been placed on the market by different manufacturers. The first of these, in the point of time is, I believe, the "Van Dorn" steel hanger, shown in Fig. 816.

*This paper was read by Mr. F. E. Kidder at a special meeting of the Colorado Chapter of the American Institute of Architects, February 27, 1903, and contains much that is of interest and practical value concerning joist-hangers and wall-hangers. This subject is an important branch of building, and should not be slighted for other details. The cuts are reproduced by courtesy of the *American Architect and Building News.*

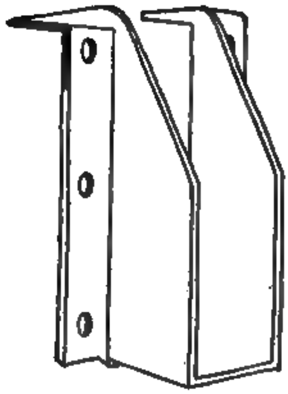


Fig. 817. The National Hanger.

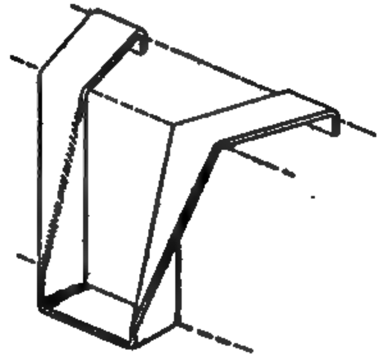


Fig. 818. The Cleveland Hanger.

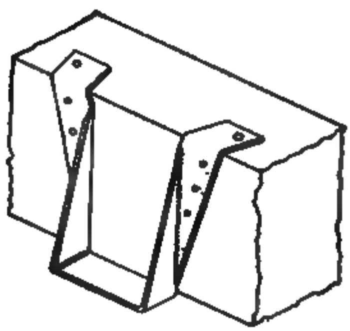


Fig. 819. The Lane Hanger.

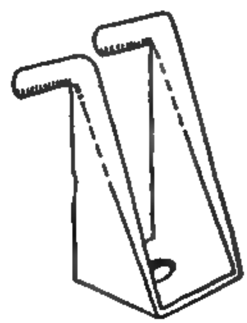


Fig. 820. The Goetz Hanger.

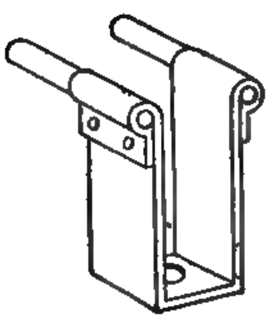


Fig. 821. The Rieseck Hanger.

Fig. 822. The Duplex Hanger for 6 by 12-Inch and Smaller Timbers.

Following this came the ' National," "Cleveland," and ' Lane" hangers, shown by Figs. 817, 818 and 819, and possibly others. All of the above, as you will see, are of the stirrup-type, but are bent and forged by machinery instead of by hand, the material used being a high grade of mild steel.

As a rule, they are neater in appearance than the ordinary stirrups, and are in many ways preferable to them, provided they are not made too light. With the single exception of the ' Cleveland" hanger, none of these forms is made to turn down over the back of the carrying-beam. They are all simply secured by spikes to the top and side of the beam.

Fig. 823. The Duplex Hanger for 8 by 12-Inch and Larger Timbers.

Fig. 824. A Duplex Wall-Hanger.

Besides these, there are the "Goetz," "Rieseck" and "Duplex" hangers, Figs. 820, 821, 822 and 823, each of the first two being, in effect, a short stirrup, but made to let into holes bored in the side of the beam just above the neutral axis; while the last two differ from all other joist-hangers, in that they are made of annealed cast iron, and in an entirely different shape. These three styles of hangers possess, in common, two advantages over all hangers of the stirrup-type; first, the settlement of the floor and ceiling from the shrinkage of the carrying-beam is only about one-half what it is where the stirrup is supported from the top of the beam, and secondly, they offer no obstruction to the flooring.

Fig. 825. A Duplex Wall-Hanger.

The matter of shrinkage is an important consideration where the ceiling is to be plastered and decorated.

When used in pairs, all the patent stirrups are connected by riveting their top flanges to a steel plate.

The "Van Dorn," "National," "Cleveland," and "Lane" hangers, when used singly over steel beams, are bent around the top flange of the beam.

The "Van Dorn" and "National" hangers are made into wall-hangers by riveting the top flanges to a steel plate, usually turned up at the back, so as to tie into the wall. The arms of the "Lane" and "Cleveland" wall-hangers are made long enough to be built 8 inches into the wall and they turn up at the back. The "Rieseck" wall-hanger is made to lie on a specially-forged steel plate with the wall-end of the arms bent down into the brickwork. The "Duplex" wall-hangers, while made on the same principle as the joist-hangers, are of very different shape, three styles being shown in Figs 824, 825 and 826.

The Effects of the Load on Hanger and Timber. The tests that have been made on single hangers of the stirrup-type, that is, those which are supported from the top of the carrying-beam, show that the first effect of loading is a compression of the timber under the top flanges. Thus, Mr. W. A. Tyrell, C.E., who made a test for Messrs. Mauran, Russel & Garden, Architects, of St. Louis, Mo., last April [1902], says of the wrought-iron stirrup, made from 3 by ⅜-inch iron, that it began to fail very early by crushing the wood on the near side and rising on the far side; and that when the load on the hanger reached 3,500 pounds it had crushed into the wood about ⅛ of an inch and had risen 1 inch. Under this load, the tensile stress in the sides of the stirrup was only 1,555 pounds per square inch, or only about one-eighth of the safe working-strength of wrought iron.

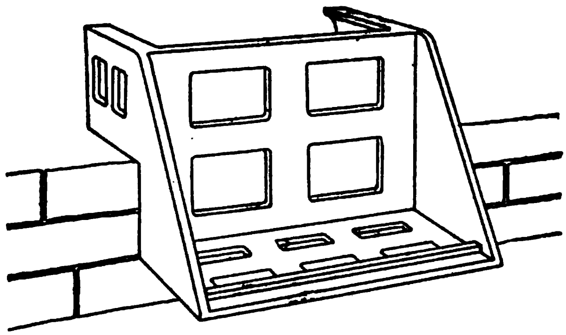


Fig. 826. A Duplex Wall-Hanger.

When the load reached 5,000 pounds, the hanger had bent to such an extent that it was in danger of slipping over the carrying-beam, and the tail-beam was blocked up. At the time of practical failure, therefore, the stress in the sides of the hanger was but 2,222 pounds per square inch.

In the test made at the Massachusetts Institute of Technology in April, 1900, a common stirrup, made from ⅜ by 2½-inch wrought iron, bent and pulled over the trimmer when loaded with 13,750 pounds or under a stress of 7,333 pounds per square inch. Fig. 815 gives a pretty fair idea of the way in which the hanger bent and of the extent to which it crushed into the carrying-beam. Of course the hanger settles with the crushing of the wood and the floor settles with it.

The stirrup tested at the Institute of Technology, although it had a smaller sectional area, offered greater resistance to the bending than one tested by Mr. Tyrell, probably because the carrying-beam was only one-half as thick in the former case as in the latter.

Theoretically, the wider the carrying-beam, the greater will be the bending moment on the top of the stirrup; but as soon as the iron lifts off from the back edge of the beam, then, of course, the bending moment is concentrated near the front edge. The tests previously referred to show that the patent stirrups fail in the same manner as the common stirrups, that is, by the crushing of the wood and the straightening out of the top flanges.

Thus, a 6 by 12-inch "Van Dorn" hanger began to straighten out under a load of 13,300 pounds, and failed, that is, slipped off, under a load of 18,750 pounds, showing a little greater resistance to bending than the common stirrup. The "Van Dorn" hanger was spiked to the carrying-beam with two spikes in each top flange, and three in each side flange. In the test made by Mr. Tyrell, a 10 by 14-inch "Van Dorn" hanger crushed down the wood at the near side, and rose at about ¼ of an inch at the ends, under a load of 5,500 pounds. This hanger also was spiked to the carrying-beam.

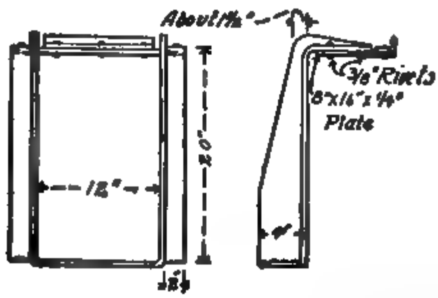


Fig. 827. Hanger that Failed in Minneapolis, Minn., Warehouse.

The Van Dorn Iron Works Company report a test in which a load of 50,000 pounds was supported by four of their 3 by 14-inch hangers without the least observable effect on the hangers; but in this case the timbers were of oak, which of all the framing-timbers, offers the greatest resistance to crushing across the grain, and the load did not reach the point at which the hanger began to fail in the test made by the Massachusetts Institute of Technology.

The shape of the hanger which failed in the Minneapolis warehouse was the same as that of the "National" hanger, and the hanger itself appeared to have been made from a 2 by 4 by ¼-inch steel angle, and to have had the 4-inch flange sheared and bent to the shape shown in Fig. 827, and the 2-inch flange entirely cut off under the seat for the beam. The top of the hanger was riveted to an 8 by 16 by ¼-inch plate by four ⅜-inch rivets through the 2-inch flange. A small angle-bar was also riveted to the rear edge of the wall-plate.

Fig. 828. Hanger that Failed in Minneapolis, Minn., Warehouse.

According to figures and sketches prepared for the *Engineering News* by Mr. G. A. Turner, M. Am. Soc. C. E., of Minneapolis, Minn., the actual load on the hanger that failed was about 15,000 pounds and failure was due to the crushing of the inner edge of the brick wall under the hanger and to the bending of the latter until it was pulled out of the wall.

Fig 828 shows the appearance of the hanger after failure, and also the distortion in the wall-plate, which was too thin to distribute the load evenly over the wall.

Attention is also called to the manner in which the bottom of the hanger was bent. This detail of the failure illustrates another weak point to be guarded against in all stirrups, where the beam is 8, 10 or 12 inches wide. In this particular instance the beam was 12 inches wide, and supported on a shelf 4 inches wide, ¼ of an inch thick and 12 inches between supports. The total symmetrically distributed load for which the beam was designed was 38,500 pounds, which would give a reaction or load of 19,250 pounds on the hanger at each end of the beam. "Considered as a uniformly distributed load, this reaction would produce a bending stress in the shelf about ten times the ultimate strength of the steel. The shelf would, therefore, be bent down so that the joist would bear only along the side edges, and these, in turn, would be crushed until the hanger became virtually a suspension-band. The stress in this band, practically pure tension, with a sag of 1 inch, would amount to nearly 30,000 pounds on a section of 1 square inch."*

When a steel stirrup cannot fail by bending and slipping from the support, it is most likely to fail by breaking at one of the bottom angles. At this point the shear is equal to one-half the load on the stirrup, and owing to the bend in the steel or iron, this is usually the weakest part of the metal.

In the warehouse at Minneapolis, the upper floor in falling carried with it the five floors below, and the hangers supporting these five floors failed at the junction of the bottom shelf with the bottom of the hanger; in most cases the bottom of the stirrup was straightened down vertically as though it were a strap, hinged to one side. These hangers were not as heavily loaded as those supporting the sixth-story floor beams, and probably had not suffered any deformation at the time the failure occurred; and the sudden shock caused the hangers to break at the weakest point.

The Strength of Double Stirrups. Although the bending-effects in a double stirrup are similar to those in a single stirrup, particularly in the bottom shelf, they cannot slip over the carrying-beam, for the reason that they are double, and the metal must necessarily break, therefore, before the beams can fall. The only test on a double stirrup that has come to my knowledge is one made by the Otis Steel Company, of Cleveland, Ohio, on November 9, 1900. The stirrup in this case was made to receive two 8 by 12-inch timbers, and to rest over a 12 by 14-inch girder. The metal was ⅜ by 2½-inches in cross-section, bent and twisted in the usual way. Under a load of 57,650 pounds on both beams, the stirrups broke at one of the lower corners, showing that the weakest point is at these corners, as previously noted

Fig. 829. The Common Stirrup-Hanger.

The girder was compressed 5/16 of an inch where the stirrup was applied, the bottom of the stirrup† bent ½ an inch and the top about the same as shown in Fig. 829.

**Engineering News*, November 20, 1902.

†This stirrup and also the stirrup shown in Fig. 815 were exhibited at the meeting.

The tensile stress in the sides of the stirrups at the time of failure was 15,732 pounds per square inch.

The Strength of the "Goetz" Hanger. I know of no definite tests of the strength of the "Goetz" hangers, but have been told that the slanting hook has a more injurious effect on the carrying-timber than if it were at right-angles to the face of the beam.

The circular section of the hooks offers a greater resistance to a bending stress than a flat or rectangular section of the same area. Round pins also do not appear to crush into the timber as much as flat bars.

The Strength of the "Rieseck Hanger." I know nothing of this hanger except what is stated in the manufacturer's circular, and no tests are quoted.

There is probably no question as to the strength of the strap, when the beams are not more than 8 inches thick. The only criticism that I have to make is the tendency to the development of a large bending moment on the arms and the relatively great leverage which they must exert on the top of the carrying-beam. If the arms were solidly fixed in an unyielding material, the theoretical bending moment on each arm would equal one-half of the load multiplied by one-half of the width of the strap. Practically, the bending of the floor-beam will naturally throw a large proportion of the weight on the outer edge of the seat, and this will increase the bending moment, and thus bring a considerable pressure on the outer fibers of the carrying-beam; and any crushing of the latter will still further increase the bending moment. Without wishing to injure the reputation of the hanger, I do not think this is as good a pattern as the "Goetz" hanger.

The Strength of "Duplex" Hangers. When these hangers were first put on the market, many persons were afraid that, being of annealed cast iron, they would be unreliable, and it was also feared that the holes bored into the carrying timber would weaken it.

As to any possible danger resulting from imperfect annealing, there is this to be said: many millions of these hangers are now in actual use in buildings, a great many of them having been in place from eight to ten years, and the only accident resulting from their use that is known to have occurred was at the Sears-Roebuck building in Chicago, Ill., where a wall-hanger designed for beams from 10 by 10 to 10 by 16 inches in cross-section was used to support a 19 by 16-inch flitch-plate girder, loaded with pressed brick and cement weighing about 1,000 pounds per square foot.

I have also been assured by the manager of the Company that every hanger is thoroughly tested before it leaves the factory.

The strength of the "Duplex" hangers, as shown by the carefully conducted tests, exceeds that of the stirrup-hangers, when made of the usual thickness of metal, that is, when the strength of the stirrup is measured by its resistance to bending; and they crush the wood less than any other hanger.

In the tests conducted by Charles E. Fuller at the Massachusetts Institute of Technology, in April, 1900, one 4 by 12-inch "Duplex" hanger failed under a load of 13,600 pounds by the breaking out of the bottom of the hanger.

Another hanger of the same size failed under a load of 14,360 pounds by breaking off under the nipple.

As the safe distributed load for a long-leaf Southern pine beam, 4 by 12 inches in section and 12 feet in length, is 9,600 pounds, the end-reaction would be 4,800 pounds, so that the hangers have a safety-factor of about three for that length of beam; while for a white-pine beam of the same length the safety-factor would be nearly five.

A No. 35, two-part "Duplex" hanger tested at the same time failed under a load of 39,550 pounds, by one side breaking off short under the nipple.

In the test made by Mr. Tyrell, at St. Louis, Mo., a No. 75 "Duplex" hanger carried a load of 38,000 pounds without any apparent effect on the hanger.

I have the statement from the Duplex Hanger Company that they have

tested their No. 75 hanger to over 60,000 pounds without a sign of fracture; this would be equivalent to a distributed load on the joist of 120,000 pounds, or over 600 pounds per square foot over a 12 by 16-foot area.

We will now look at the effect on the carrying-beam of the holes bored for the nipples.

In the case of the two 4 by 12-inch hangers tested, the load had no injurious effect on the header except to slightly compress the bottom of the hole. In the case of the No. 35 hanger a slight longitudinal crack appears to have been developed about opposite the center of the holes and the bottom of the holes to have been compressed about $\frac{1}{16}$ of an inch.

During the test of the No. 75 hanger, at St. Louis, when the load reached 27,360 pounds, a slight crack was developed in the girder between the spools, and extended a short distance on both sides. Under the final load of 38,000 pounds this crack increased slightly in length and width, and the washers on the far side sank about ⅛ of an inch into the timber. The joist was crushed about ¼ of an inch where it rested on the hanger.

From these tests, and from general observations taken where the hangers have been used in actual construction, the holes for the spools do not appear to have any injurious effect upon the carrying-beam, until the loads exceed the safe loads for the timber beams and girders.

The only case in which the weakening effect of these spools need to be considered is the one where a number of the larger hangers are used close together; and in this case it would seem wise to increase the thickness of the carrying-timbers sufficiently to make good any weakening effect of the holes. This would also be true in regard to the "Goetz" and "Rieseck" hangers.

Conclusions. The conclusions that may be fairly drawn from the preceding analysis are in part, at least, as follows:

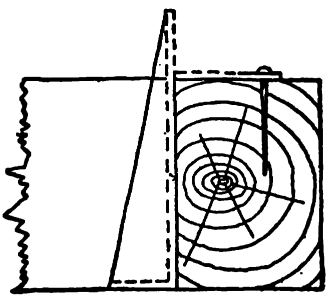


Fig. 830. Suggestion for Ideal Type of Hanger.

(1) It is impossible to determine the safe carrying capacity of a stirrup-hanger directly from the tensile strength of the steel or iron, unless better provision is made for uniformly distributing the load over the top shelf. The ideal stirrup would be constructed with a bracket above the hooks, as in Fig. 830, strong enough to prevent the latter from straightening; and in this case the full stress would be thrown on the lower angles of the steel or iron. This has been attempted to some extent in the "National" hanger.

(2) It is not advisable to use less than a ⅜-inch thickness of metal for common stirrups, except where light beams are to be supported.

(3) The patent stirrup-hangers are, as a rule, made too thin.

(4) Wherever a stirrup is used to support a heavily loaded timber, or the end of a truss or girder, the bearing of the metal on wood, the resistance to bending or straightening of the top hook, or flanges, and the shearing or tearing of the metal at the bottom corners should all be very carefully considered.

(5) The "Duplex" Hangers give ample strength for the size of beams for which they are intended, except possibly where a very short beam is loaded to its full capacity, in which case the load on the hanger should be computed and compared with the data given above.

The advantage of the "Duplex" and "Goetz" hangers in lessening the settlement due to shrinkage in the carrying-timber has already been referred to.

In regard to wall-hangers, the same principles apply to them as to joist-hangers, the best hanger being that which is designed so as to most perfectly

distribute the load over the bearing-surface of the masonry, and which at the same time possesses the requisite tensile strength in the sides and bottom. For distributing the weight on the wall, there is certainly no wall-hanger now on the market which approaches the "Duplex," and if steel hangers could be economically made on the same pattern they would result in an ideal construction.*

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*Since the above article was written a steel hanger has been invented and made according to the suggestions of Mr. Kidder in the final paragraph of his conclusions. This use of hanger seems to verify the predictions made for it by the author, a number of tests made at Columbia University, under the supervision of Professor R. K. Wilson, as well as the fire-tests, made under the direction of the National Board of Fire Underwriters apparently demonstrating its superiority.

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